Proceedings of the I·R·E

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Bridging Snowy Wastes

MARCH 1943

VOLUME 31 NUMBER 3

Wartime Service

F-M Tuning Indicators

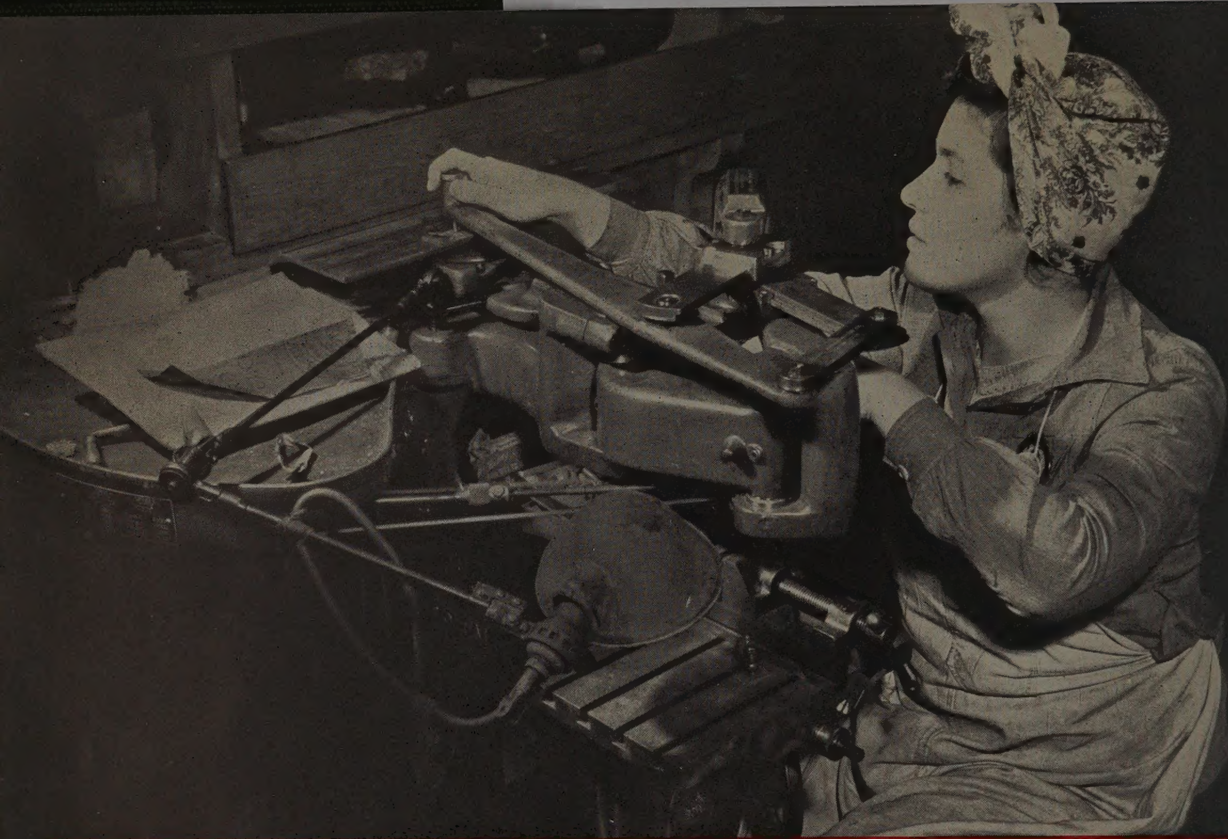
Wartime Broadcast Operations

Television View Finders

Television Studio Lighting

Distortion Meter

Institute of Radio Engineers



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The Institute of Radio Engineers

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Wartime Service

To the Membership of the Institute From the Board of Directors

For the second time in the life of the Institute, we have laid aside the tasks of peace and turned to the grimmer needs of war. Inevitably this radical change imposes on us strict obligations and offers us inspiring opportunities.

On its part, the Board pledges itself to conduct the affairs of the Institute with the wholehearted purpose of making the maximum contribution to the war effort. In so doing, the Board fully recognizes that it is living up to the wishes and determination of the membership.

Manifestly we cannot have—and until victory comes, we do not wish—"engineering as usual." The myriad of new and interesting radio-and-electronic devices for peacetime purposes of which we can conceive are largely banished from our thoughts as they are from our daily work. The needs of our Armed Forces occupy our closest attention to the exclusion of all else. And this is as it should and must be.

There are many ways in which we can serve. To some of us is given the privilege of active service as officers or men in the Military Services. All can understand the meaning and standing of such service and justly appraise its worth.

To others is granted the opportunity to act as civilian experts or employees of the Army or Navy. And here again only the dullest would fail to appreciate the national value of such services and their wartime appropriateness.

And to many of us is accorded a different task which, to some at least, is not so clearly meritorious and praiseworthy. Far behind the lines—some in secluded and quiet laboratories, offices, and drafting rooms, some close to the busy production line—many of our numbers are carrying on their wartime services. For them there is neither the excitement of danger nor the glamour of applause and fame. Ready understanding, sympathy, and community approval are seldom for them. Yet they too serve, and serve truly and well. But for their toil, the incredibly huge aggregation of equipment needed for modern warfare would be missing at the front—and with tragic consequences.

To those in the Armed Forces, as military or civilian personnel, the Board extends its respects and its most hearty wishes for success. And to those others often working in obscurity and tempted, it may be, to forsake their tasks for brighter ones, the Board offers its full understanding and sincere commendation.

May both these groups of engineers continue to stand shoulder to shoulder, in a brotherhood which is none the less real for being intangible, until that day of triumph when they shall again be united in homes and working places.

For the Board of Directors
***Lynde P. Wheeler*, President**

February 3, 1943

Photo by U. S. Army Signal Corps

Charles McKinley Saltzman

1871–1942

Major-General Charles McKinley Saltzman, chairman of the Federal Radio Commission from 1930 to 1932, and Chief Signal Officer, U.S.A., from 1924 to 1928, died on November 25 in Washington, D. C.

General Saltzman was born at Panora, Iowa, on October 18, 1871. After his graduation from West Point in 1896, he saw service in the Spanish-American War and the Philippine Insurrection. He was given two citations for "gallantry in action" in the Spanish-American War and awarded the Distinguished Service Medal for "exceptionally meritorious and conspicuous services" during World War I. He was also awarded the Silver Star with oak-leaf cluster for gallantry in action.

In 1901 he transferred to the Signal Corps and in 1912 he was a member of the Interdepartmental Board that formulated the first regulations for the control of radio in the United States.

General Saltzman was a delegate to numerous international radio conferences from 1912 on. In 1929 he was appointed to the Federal Radio Commission and instituted its reorganization. From 1930 to 1932 he served as its chairman.

Shortly after his resignation from the Commission, he was recalled in 1933 to prepare a report on the regrouping and consolidation of government agencies with particular reference to those concerned with transportation and communication. As chairman of a special interdepartmental committee, he submitted a report on the communication facilities of the country which, transmitted to Congress by the President, resulted in the Federal Communications Commission, an agency which he had persistently recommended.

Tuning Indicators and Circuits for Frequency-Modulation Receivers*

JOHN A. RODGERS†, ASSOCIATE, I.R.E.

Summary—**Frequency modulation provides good reception, but requires operation at resonance. The circuits described in these pages are applicable to standard receivers and provide effective means for accurate tuning. Some of these circuits include additional diodes, triodes, and combinations of diodes and triodes to produce sharp determination of the discriminator crossover point. A novel tuning eye employing two grids is suggested for a simplified tuning indicator.**

Tuning a Frequency-Modulation Receiver

THOSE who have had occasion to use a frequency-modulation receiver are aware of the necessity for a good visual tuning indicator. Here it is a case of "must," since reception exists for such an extended range around the correct tuning point. The results of mistuning are quite different in the case of frequency modulation. Here there is little change in audio-frequency characteristic and the volume level remains essentially constant as the receiver is tuned in and out of resonance.

At resonance, the noise is at a minimum and so also is the distortion. Slight mistuning may cause only a small increase in the ordinary type of background noise, but the high audio frequencies and all frequencies fully modulated will be noticeably distorted. The reason for this is that the frequency-modulation detector is a balanced circuit and depends upon exact resonance to deliver undistorted signals to the audio amplifier. This balance likewise results in the canceling out of amplitude changes, which are the unwanted responses, such as noise. Just how effectively the

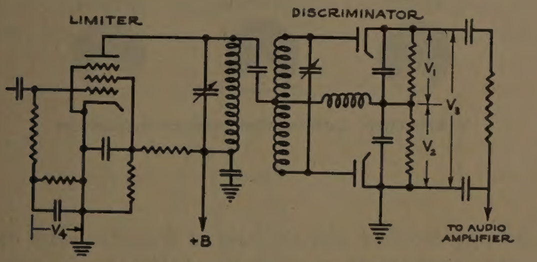

Fig. 1—Conventional frequency-modulation circuits.

frequency-modulation radio eliminates interference, then, depends to a very large extent upon this balance of the discriminator. With even slight mistuning, the ignition of a passing car will produce an annoying staccato that would not be audible with the receiver tuned to resonance.

It is logical to assume, then, that if we are going to take advantage of all the benefits which frequency modulation affords—extended frequency range, increased dynamic range, decreased distortion, and freedom from noise—we must tune the receiver to exact resonance and there must be some means provided for indicating this condition.

Simplified Type of Indicator

The first and simplest method is similar to that used with the amplitude-modulation receiver. The grid of

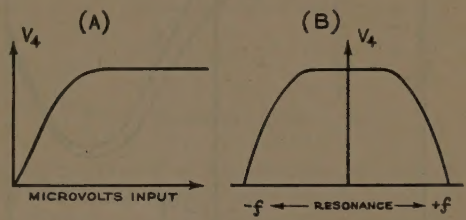

Fig. 2—Limiter rectified grid voltage.

the eye tube receives voltage V_4 from the limiter grid circuit (Fig. 1) and will, therefore, indicate the peak of the over-all selectivity curve. This is an indirect method of approach because the correct tuning point is the balance of the detector and this method assumes that the receiver is and remains perfectly aligned throughout, so that the selectivity curve is perfectly symmetrical and the discriminator curve is centered upon it.

In actual practice it has not only been found impossible to keep the over-all selectivity characteristic sufficiently symmetrical, but the curve shape will alter as the strength of the incoming signal changes. Moreover the selectivity curve is so broad that the eye is insensitive and on very strong signals a glance at the curve in Fig. 2 (B) will show how little aperture change can be expected for quite a departure from resonance.

However inadequate this method may seem, it is still better than no indicator at all and has been used with some degree of success on many receivers.

Circuits for Accurate Tuning

The direct method utilizes the voltages from the discriminator and of necessity involves greater complication. Exact resonance occurs when the incoming wave is centered on the detector curve so that, according to Fig. 3, V_3, the sum of voltages V_1 and V_2, is zero. These are direct voltages.

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† Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y.

By actually placing a voltmeter, preferably of the center-zero type, directly across the discriminator load, the receiver may be tuned accurately. However, the meter has been considered unsuitable and the next step is to find out how the tuning eye can be utilized. If its grid is connected to the high side of the discriminator load, voltage V_3 will cause the aperture to increase and decrease but there will be no way of determining where the zero-voltage point occurs. It is therefore necessary to establish some zero-voltage reference point. This may be done in several ways.

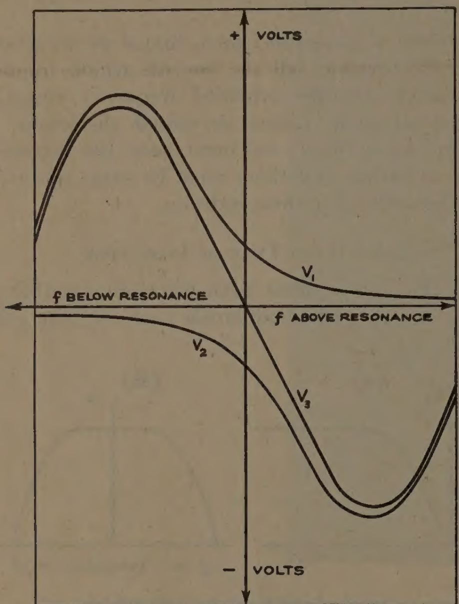

Fig. 3—Discriminator voltages.

The tuning indicator can be operated with an initial fixed bias sufficient to close the aperture when the voltage V_3 from the discriminator is zero. When V_3 becomes positive then, the eye will open and when V_3 swings negative, the eye will overlap. Thus the point of zero voltage or correct tuning is established. Some form of potentiometer must be provided with this method, since changes in line voltage, tube characteristics, etc., will require a readjustment of this reference point.

An alternative means of accomplishing this same function but avoiding the necessity of regularly checking the zero points consists in providing enough bias voltage to close the eye part way. A switch is then placed across the discriminator load so that when closed, the voltage on the eye grid is zero. By tuning the receiver until the tuning indicator aperture is the same for both positions of the switch, the correct point for true resonance is assured.

Since a manually operated switch is undesirable, it may be replaced by a contactor of special design such as shown in Fig. 4. This is a vibrating contact operating on alternating current to produce rapid intermittent short-circuiting of the tuning indicator grid to ground. The result is two eye apertures, one remaining fixed and representing the interval when the grid is grounded and the other opening and closing according to the voltage V_3. Correct tuning will occur at the point where these two apertures coincide.

A desirable variation here is shown by the dotted line, where the negative voltage for the initial bias is supplied by the limiter grid circuit. Because the bias from the limiter is zero when no station is being received, the tuning indicator is wide open, but narrows as a station is approached on the dial. This circuit change makes operation less confusing, since there is a difference then between the condition where no station is being received and the case of reception with the radio tuned exactly to resonance, both occurring when V_3 is zero.

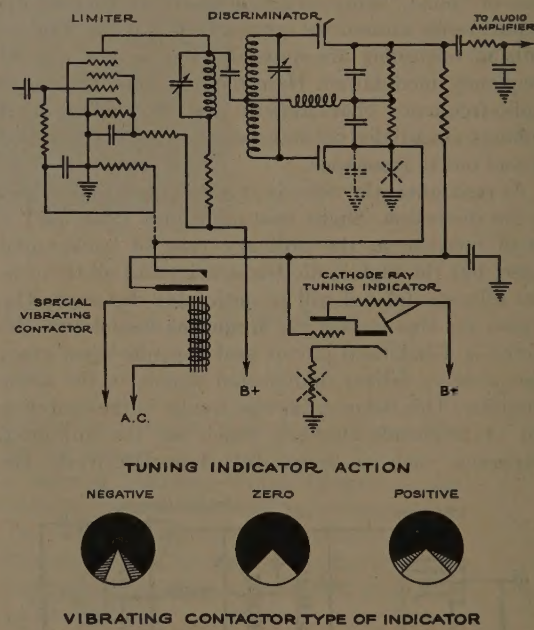

Fig. 4

Another method is to put the positive and negative discriminator voltages through special circuits so that they will each produce a voltage in the same direction. This is shown in Fig. 5 where a double diode and double triode are used in addition to the indicator tube.

Here the detector voltage is impressed upon the cathode of one diode and the plate of the other, the two other corresponding electrodes being grounded through resistors across which voltages are developed and impressed upon the triode grids. It is apparent

that through the unidirective action of each diode, one triode will receive only negative voltage and the other only positive. The latter, therefore, will have its plate current increased with a consequent lowering of the plate voltage through an increased drop in the load resistor. This will decrease the voltage on the focusing

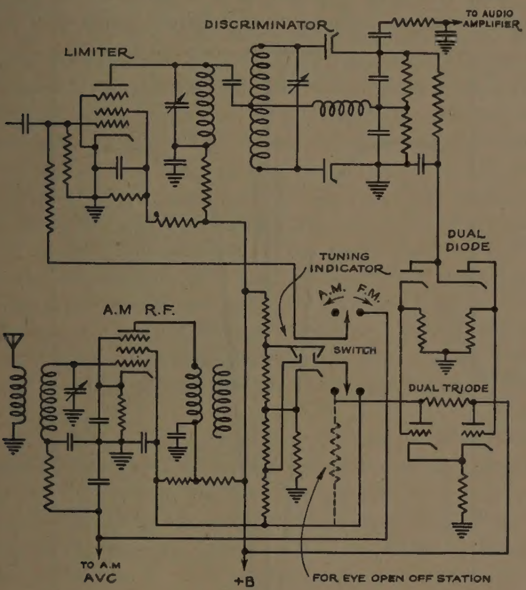

Fig. 5—Dual-diode and dual-triode indicator circuit.

electrode of the tuning indicator, since it is attached to this triode plate, and the eye aperture will increase. In a like manner, a negative voltage at the discriminator will tend to decrease the plate current of the second triode and thereby reduce the voltage drop in the cathode resistor, effectively decreasing the bias on the first triode to produce the same effect again. Therefore,

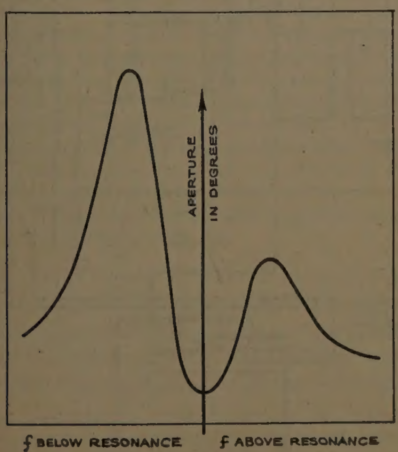

Fig. 6—Indicator aperture angle using circuit of Fig. 5.

on either side of resonance the eye will open and good reception can be assured in the regular manner by tuning for the greatest closing of the eye.

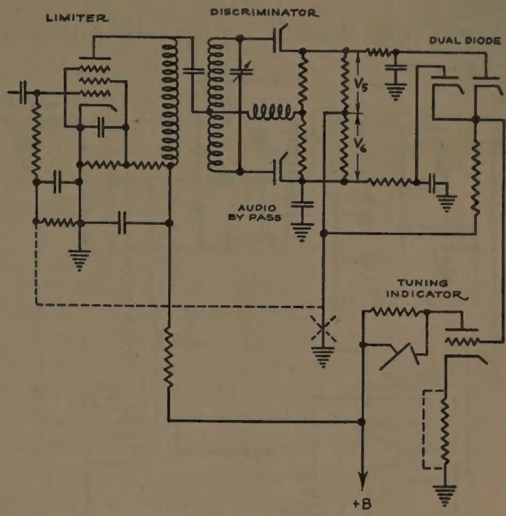

Fig. 7—Dual-diode indicator circuit.

By proper choice of resistors, the eye can be just closed for the condition of zero voltage across the detector. This is an extremely sensitive tuning device, more so than the voltmeter, and requires no preliminary setting up.

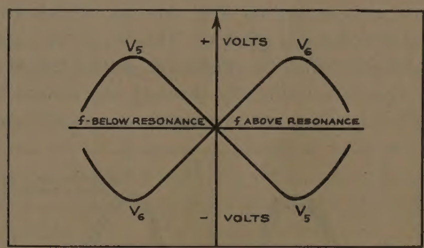

Fig. 8—Discriminator voltages.

The second portion of the eye is actuated by the biasing of an auxiliary tube with the negative voltage derived from the limiter grid circuit and may be omitted, of course.

Since the first section of the tuning indicator is closed when no signal is received as well as for the condition of exact resonance to a received signal, the operation may be confusing. However, this can be overcome by the addition of the resistor shown dotted in Fig. 5. This reduces the voltage of the electrode controlled by the discriminator when no station is being received. As a signal is approached the voltage on the electrode connected to the single triode rises because of the increase in bias voltage supplied from rectification in the limiter grid circuit. The voltage on the discriminator-controlled electrode will also rise because of

the connecting resistor, so that when the station has been correctly tuned, the combination of effects will result in both apertures of the tuning indicator being closed.

A curve of the change in aperture angle with tuning

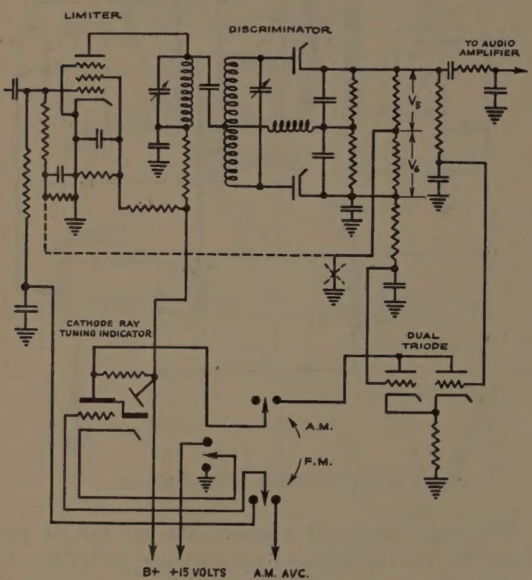

Fig. 9—Dual-triode indicator circuit.

is shown in Fig. 6 and it will be observed that the effect is more pronounced on the side for which the discriminator voltage is positive. This would be expected, since a direct effect is produced, while the negative voltage operates indirectly through the second triode. However, the lack of symmetry does not interfere

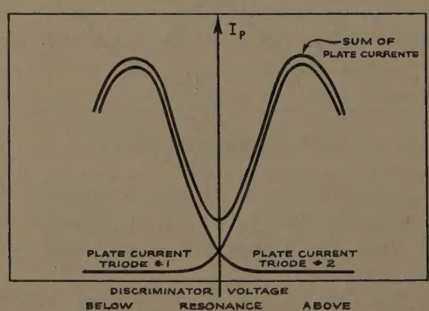

Fig. 10—Plate-current characteristics of dual-triode in Fig. 9.

with the effectiveness of the indicator, since it lies outside of the close-tuning area.

In Fig. 7 is shown a relatively simple yet useful circuit whereby the positive and negative detector voltages are both converted to positive voltages and then impressed on the eye-tube grid. It will be noticed that the direct-current ground has been removed from the cathode of the discriminator diode and has effectively been placed at the electrical center of the load so that the voltages with respect to ground are of the form shown in Fig. 8. A by-pass condenser is used to ground the low side of the discriminator load for audio frequencies, as it is still necessary to deliver the full amount of detected audio frequencies to the audio amplifier.

With this type of indicator it is necessary to use a sharp-cutoff eye tube so that sufficient sensitivity can

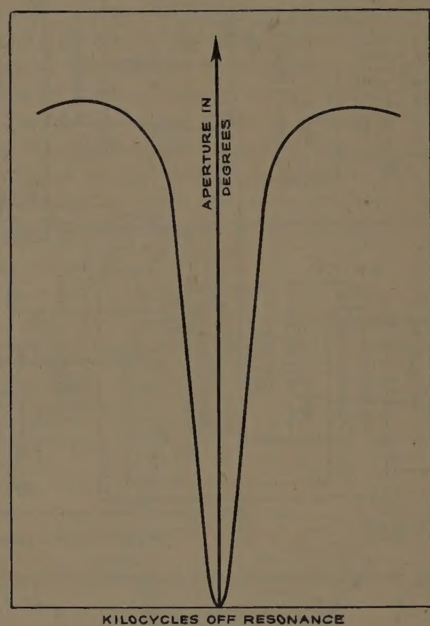

Fig. 11—Tuning indicator aperture angle with circuit of Fig. 9.

be obtained for accurate tuning. In combination amplitude-modulation and frequency-modulation receivers

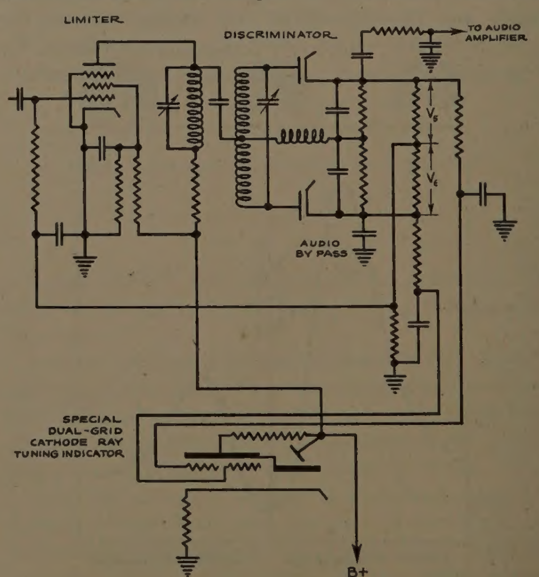

Fig. 12—Indicator circuit using special eye tube.

where the same indicator tube would logically be used, this imposes an undesirable restriction, since amplitude modulation requires an indicator tube of the remote-cutoff type.

Better results may be obtained with the use of the circuit shown in Fig. 9 where a dual sharp cut-off triode receives the voltages of Fig. 8. It can be seen from the curves that when one grid is positive, the other is negative by an equal amount and at first thought it would seem that any effect produced on the tuning indicator by one triode would immediately be canceled by the other. However, since these triodes are operated in the region of plate-current cutoff, the negative grid voltage from the discriminator produces a negligible plate-current change but the corresponding positive voltage on the other grid causes an abrupt plate-current rise. The two plate-current curves are shown in Fig. 10 and added to give the total current flowing in the load resistor. The plate voltage, which the focusing electrode receives, is of the same form and the over-all tuning characteristic appears in Fig. 11.

Not only is this type of indicator symmetrical, but also extremely sensitive. Here again by using a portion of the limiter grid voltage, the eye can be open when no station is being received and closed only when a signal is correctly tuned. This variation is shown dotted in Fig. 9.

If it is found desirable to use the more frequently found tuning indicator with the remote-cutoff triode in the same envelope, provision must be made for biasing this unwanted triode beyond plate-current cutoff, since it is connected internally to the focusing electrode and the slightest conduction will render the indicator circuit insensitive.

If an indicator tube of the sharp-cutoff type is used, however, the included triode will form one branch of the circuit and only a single additional triode will be required.

Special Indicator Tube

Proceeding a step farther by designing a special indicator tube for this service, the function can be performed with a minimum of equipment as shown in Fig. 12. Here a sharp-cutoff indicator tube with two identical grids is used in the same manner as the separate dual triode and eye tube in the circuit previously described. This functions very well for frequency modulation but is unsuited to the remote-cutoff requirements of amplitude modulation.

The possibility exists of making one of these indicator tubes with two sharp-cutoff grids and a third remote-cutoff grid to be used especially for combination amplitude-modulation—frequency-modulation receivers with a consequent saving in tubes but such an eye has yet to be designed.

Maintenance of Broadcast Operations in Wartime*

J. A. OUIMET†, ASSOCIATE, I.R.E.

Summary.—**This paper deals with the technical measures which have been taken in Canada by the Canadian Broadcasting Corporation to meet the daily increasing difficulties of maintenance of broadcast operations in war time. After a brief description of the facilities involved in these plans the paper outlines the steps that have been taken in the physical protection and guarding of broadcast plants. The problem of conservation of equipment in the face of acute shortages is then discussed with the measures that have been applied to prolong the life of tubes, microphones, and other equipment. In treating the final aspect of the problem, that is, the maintenance or resumption of essential operations after destruction of regular facilities, the paper describes the setting up of emergency and stand-by facilities such as secondary control centers, stand-by transmitters, frequency-modulation links, and other equipment designed to insure continuity of service.**

FOR THE Canadian Broadcasting Corporation, the problem of maintaining its operations in wartime is essentially the same as that which faces American broadcasters. It is confronted with the same serious economic difficulties, with the same dangers of sabotage, and finally with the same possibilities of enemy action which may bring about the destruction of its facilities.

Compared to the individual broadcasting station, however, there is one important difference, and that is, its much greater obligations as a publicly owned national service. The Canadian Broadcasting Corporation has been created as an independent, nonprofit-making institution responsible to the Canadian Government to provide a national broadcast service to all Canadians; this service, which is now even more vital than ever before, must be maintained whatever may be the difficulties which rise in its path. For this reason it may have gone more deeply into the problem than has the average station and has concerned itself, not only with measures of plant protection and equipment conservation, but also with measures designed to insure continuity of service in the event of destruction of some of its facilities.

With 10,000 miles of transmission lines operating through five time zones, the CBC network extends from Sydney, Nova Scotia, to Vancouver in British

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† Assistant Chief Engineer, Canadian Broadcasting Corporation, Montreal, Que., Canada.

Columbia and links together a total of 57 stations. (See Fig. 1.) Of these, 36 are basic outlets and 21 are supplementary; 47 are privately owned, and 10 are owned and operated by the CBC. Four are 50-kilowatt transmitters: CBA, located at Sackville, is the Regional outlet for the Maritime provinces; CBF, near Montreal, is the French outlet for the province of Quebec; CBL, near Toronto, is the Ontario Regional station, and finally CBK, at Watrous, serves the three Canadian Prairie provinces. In addition, there are stations of either 5 kilowatts or 1 kilowatt at Vancouver, Toronto, Ottawa, Montreal, Quebec, and Chicoutimi, as well as three short-wave stations. These CBC stations represent 71 per cent of the total power of all Canadian stations and cover 85.5 per cent of all Canadian radio homes. To produce the programs which feed this network, the CBC has studio installations in Vancouver, Winnipeg, Toronto, Ottawa, Montreal, Quebec, Chicoutimi, and Halifax. This is further supplemented by international exchanges with the American networks and the British Broadcasting Corporation. Programs from England and particularly from the CBC Overseas Mobile Unit are received at a four-channel short-wave diversity receiving station located near Ottawa. To man these facilities, a technical staff of more than 150 people is maintained, exclusive of the engineering personnel of its headquarters in Montreal.

Fig. 2—Gate at CBF transmitter, showing protecting fence, armed guard, and guardhouse.

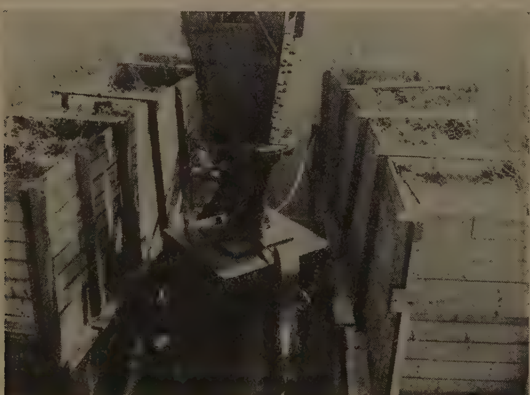


Fig. 3—Sand barricade protecting base insulator of CBF vertical radiator.

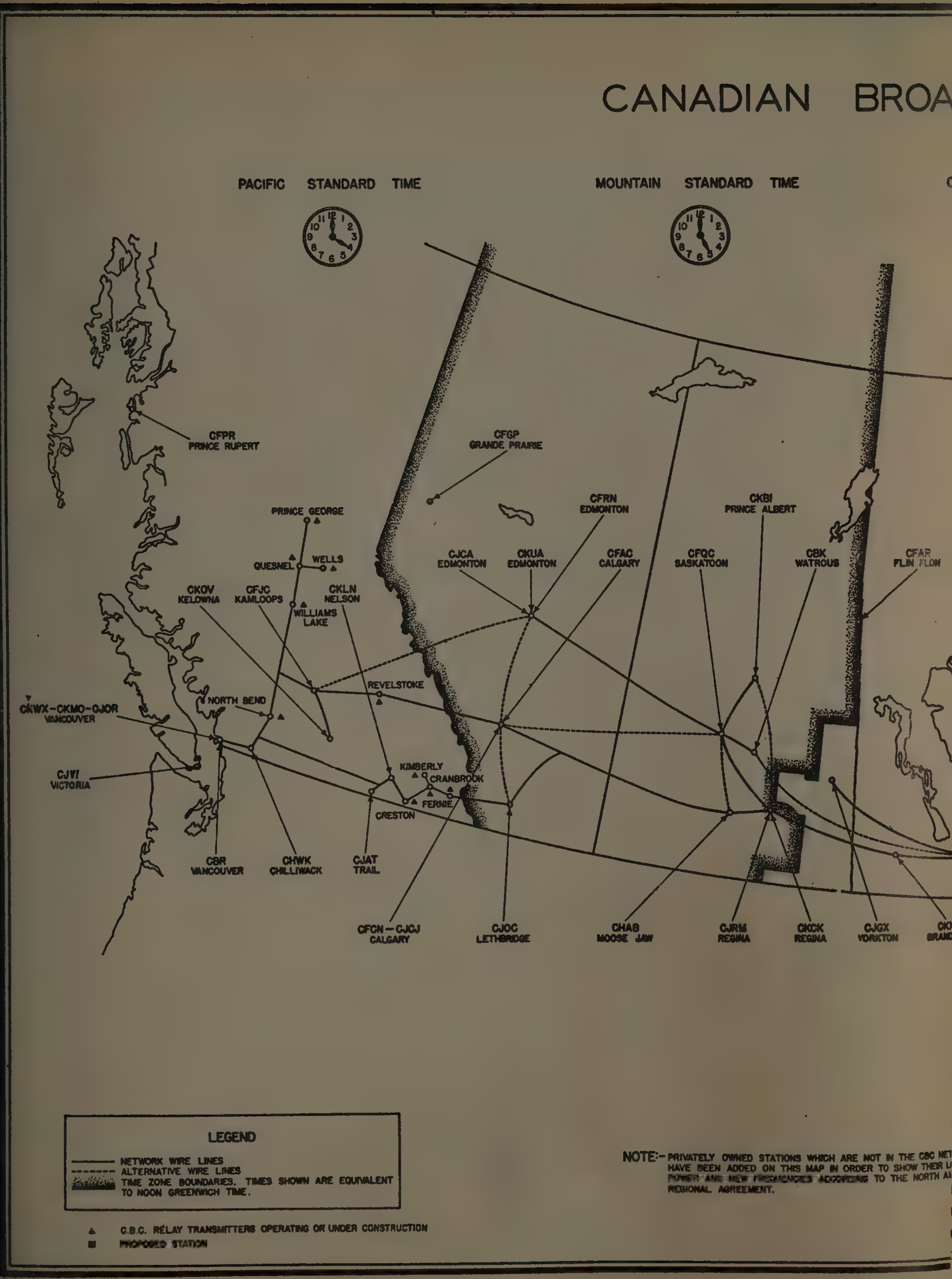
The first wartime measures were introduced right at the start of the war, in the fall of 1939, and were directed against possible sabotage. These included the construction of barbed-wire fences, the installation of floodlights, the erection of sandbag barricades, and finally the establishment of armed guards at all main outside plants.

Fig. 4—Sand barricade in front of glass-brick section of CBF transmitter building.

For reasons of economy these fences do not enclose all of the transmitter grounds but only that portion which contains vital components such as the transmitter building, transmission line, antenna, guy anchors, and power substation. However, the fences are kept sufficiently far away from any of these points to guarantee the desired protection. The fence itself is of simple and cheap construction, about seven feet high, using steel posts and barbed wire. (See Fig. 2.)

Armed guards are on duty at all times and access to the plants is restricted to the identified personnel of the corporation. Others can be admitted only for special serious reasons and must show passes which are issued only after thorough investigation. Because of our rigorous climate it has been necessary to provide small heated guardhouses where the men on duty can recuperate between their rounds. (See Fig. 2.)

The floodlighting used is simple and has been designed only for protection purposes and not for decoration or publicity. Its function is to provide sufficient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PACIFIC STANDARD TIME
MOUNTAIN STANDARD TIME
CFPR PRINCE RUPERT
CFGP GRANDE PRAIRIE
PRINCE GEORGE
QUESNEL
WELLS
CFRN EDMONTON
CKBI PRINCE ALBERT
CJCA EDMONTON
CKUA EDMONTON
CFAC CALGARY
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CBK WATROUS
CFAR FLIN FLON
CKOV KELOWNA
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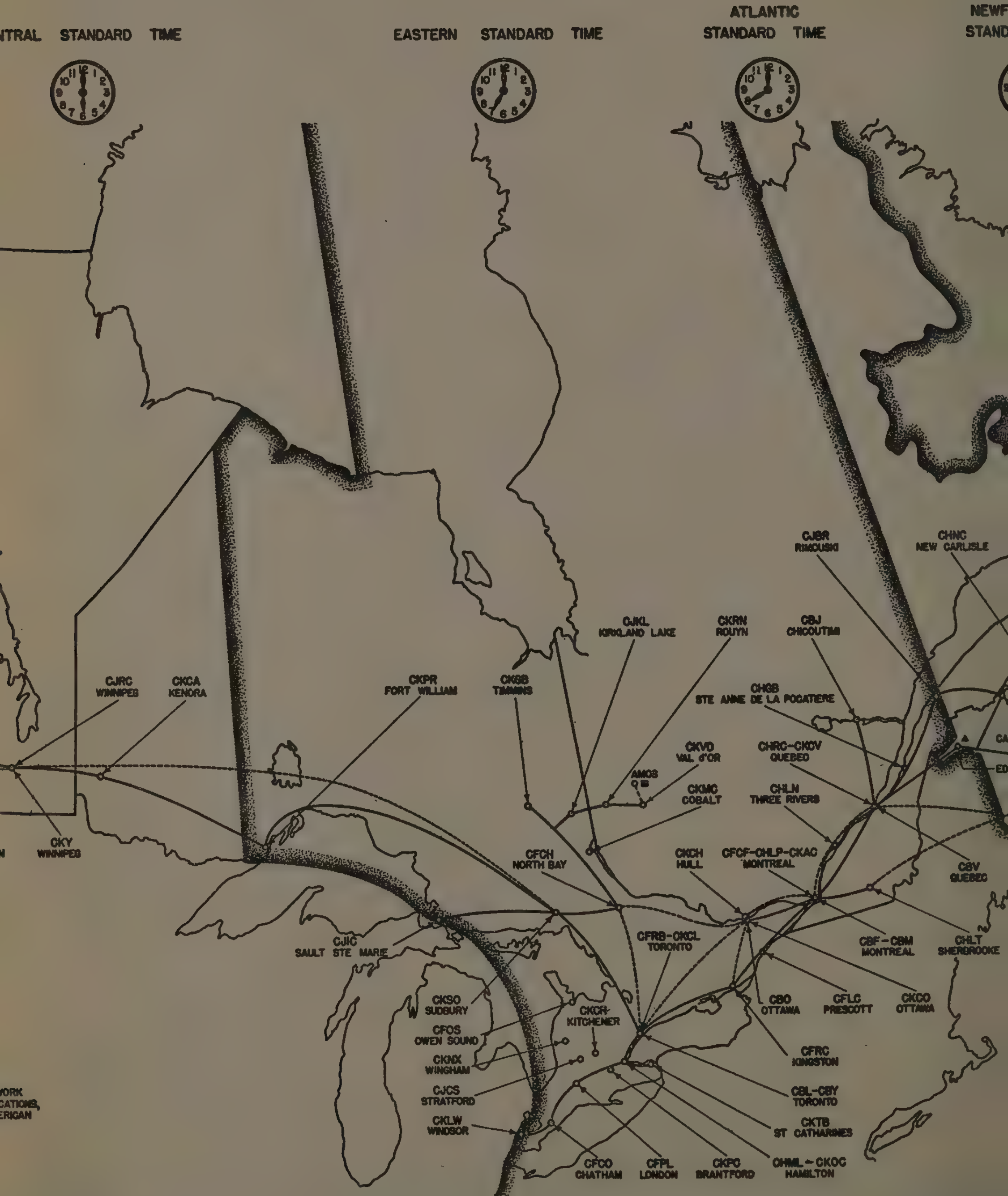
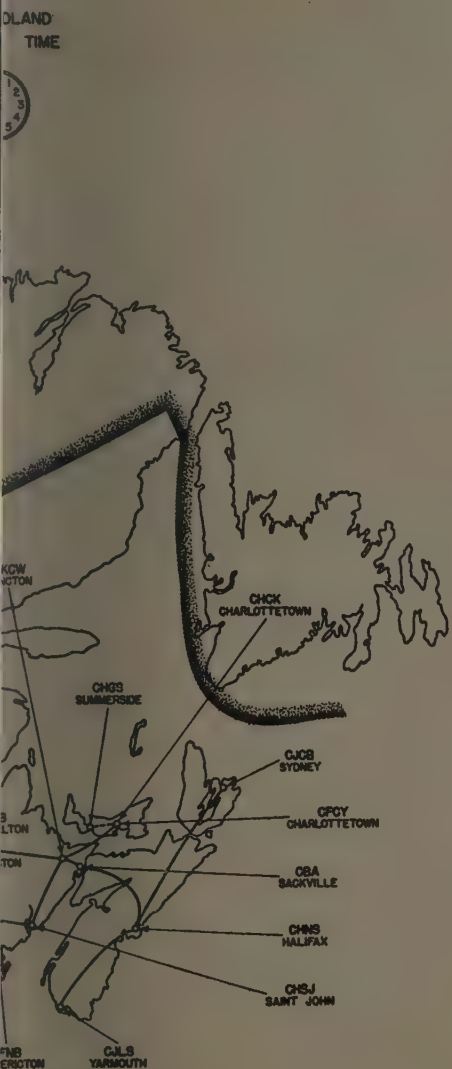
FERNIE
CRESTON
CBR VANCOUVER
CHWK CHILLIWACK
CJAT TRAIL
CFCN—CJCJ CALGARY
CJOC LETHBRIDGE
CHAB MOOSE JAW
CJRM REGINA
CKCK REGINA
CJGX YORKTON
LEGEND
NETWORK WIRE LINES
ALTERNATIVE WIRE LINES
TIME ZONE BOUNDARIES. TIMES SHOWN ARE EQUIVALENT TO NOON GREENWICH TIME.
C.B.C. RELAY TRANSMITTERS OPERATING OR UNDER CONSTRUCTION
PROPOSED STATION
NOTE:- PRIVATELY OWNED STATIONS WHICH ARE NOT IN THE CBC NET HAVE BEEN ADDED ON THIS MAP IN ORDER TO SHOW THEIR
REGIONAL AGREEMENT.

DCASTING CORPORATION NETWORK

CORRECTED TO MARCH – 29 – 1941





LEGEND

- ✱ CBC OWNED OR OPERATED STATIONS
- ● NETWORK STATIONS
- ◉ SUPPLEMENTARY STATIONS
- ○ PRIVATELY OWNED STATIONS NOT ON CBC NETWORK.

COVERAGE STATISTICS DEPARTMENT
C. B. C.

CANADIAN BROADCASTING STATIONS

Symbol	City	Call Letters	Frequency in Kilocycles	Power in Watts
	MARITIMES REGIONAL NETWORK			
✱	SACKVILLE	CBA	1070	50,000
●	CHARLOTTETOWN	CFCY	630	1,000
●	FREDERICTON	CFNB	550	1,000
●	HALIFAX	CHNS	[illegible]	1,000
●	MONCTON	CKCW	[illegible]	250
●	SAINT JOHN	CHSJ	1150	1,000
●	SYDNEY	CJCB	1270	1,000
◉	SUMMERSIDE	CHGS	1480	100
◉	YARMOUTH	CJLS	1340	100
○	CAMPBELLTON	CKNB	950	1,000
○	CHARLOTTETOWN	CHCK	1340	50
	QUEBEC REGIONAL NETWORK			
✱	MONTREAL	CBF	[illegible]	50,000
✱	MONTREAL	CBM	940	5,000
✱	QUEBEC	CBV	[illegible]	1,000
✱	CHICOUTIMI	CBJ	[illegible]	250
●	NEW CARLISLE	CHNC	610	1,000
●	RIMOUSKI	CJBR	[illegible]	1,000
◉	HULL	CKCH	1240	100
◉	ROUYN	CKRN	1400	250
◉	SHERBROOKE	CHLT	1240	250
○	MONTREAL	CFCF	600	500
○	MONTREAL	CHLP	[illegible]	100
○	MONTREAL	CKAC	730	5,000
○	QUEBEC	CHRC	[illegible]	250
○	QUEBEC	CKCV	1340	100
○	STE ANNE DE LA POCATIERE	CHGB	1230	250
○	THREE RIVERS	CHLN	1450	100
○	VAL D'OR	CKVD	1230	100
	ONTARIO REGIONAL NETWORK			
✱	TORONTO	CBL	740	50,000
✱	TORONTO	CBY	1010	1,000
✱	OTTAWA	CBO	910	1,000
●	FORT WILLIAM	CKPR	580	1,000
●	KINGSTON	CFRC	1490	100
●	KIRKLAND LAKE	CJKL	560	1,000
●	NORTH BAY	CFCH	1230	100
●	TIMMINS	CKGB	1470	1,000
●	SUDBURY	CKSO	790	1,000
◉	CHATHAM	CFCO	630	100
◉	HAMILTON	CHML	900	1,000
◉	HAMILTON	CKOC	1150	500-N-1,000-D
◉	KENORA	CKCA	1450	100-N-250-D
◉	LONDON	CFPL	1570	1,000
◉	ST CATHARINES	CKTB	1550	1,000
◉	SAULT STE MARIE	CJIC	1490	250
◉	WINDSOR	CKLW	800	5,000
○	BRANTFORD	CKPC	1380	100
○	COBALT	CKMC	1240	50
○	KITCHENER	CKCR	1490	250
○	OTTAWA	CKCO	1310	250-N-1,000-D
○	OWEN SOUND	CFOS	1400	250
○	PRESCOTT	CFLC	1450	100
○	STRATFORD	CJCS	1240	50
○	TORONTO	CFRB	860	10,000
○	TORONTO	CKCL	580	1,000
○	WINGHAM	CKNX	920	197-N-1,000-D *
	PRAIRIE REGIONAL NETWORK			
✱	WATROUS	CBK	[illegible]	50,000
●	BRANDON	CKX	1150	1,000
●	CALGARY	CFAC	960	1,000
●	EDMONTON	CJCA	930	1,000
●	LETHBRIDGE	CJOC	1400	100
●	MOOSE JAW	CHAB	1220	1,000
●	PRINCE ALBERT	CKBI	900	1,000
●	REGINA	CKCK	620	1,000
●	SASKATOON	CFQC	600	1,000
●	WINNIPEG	CKY	990	15,000
◉	CALGARY	CFCN	1010	10,000
◉	CALGARY	CJCJ	1230	100
◉	EDMONTON	CFRN	1260	1,000
◉	REGINA	CJRM	980	1,000
◉	WINNIPEG	CJRC	630	1,000
◉	YORKTON	CJGX	1460	1,000
○	EDMONTON	CKUA	580	1,000
○	FLIN FLON	CFAR	1400	100
○	GRANDE PRAIRIE	CFGP	1340	250
	BRITISH COLUMBIA REGIONAL NETWORK			
✱	VANCOUVER	CBR	1130	5,000
●	KAMLOOPS	CFJC	910	1,000
●	KELOWNA	CKOV	630	1,000
●	TRAIL	CJAT	610	1,000
◉	CHILLIWACK	CHWK	1340	100
◉	NELSON	CKLN	1240	100
○	PRINCE RUPERT	CFPR	1240	50
○	VANCOUVER	CJOR	600	1,000
○	VANCOUVER	CKMO	1410	100
○	VANCOUVER	CKWX	980	1,000
○	VICTORIA	CJVI	1480	500

ABBREVIATIONS:- N... NIGHT TIME POWER
D... DAY TIME POWER

* Temporary pending installation of Directional Antenna.

Revised May 1, 1942
Revised February 1, 1942
Revised November 13, 1941

illumination to those parts of the property which are considered vulnerable to enable the guards on duty to detect any moving person from any location covered in their rounds.

Finally, to protect vital parts against destruction by explosive projectiles that may be directed from outside of the fenced enclosure, sand barricades have been erected around the guy anchors and at the base insulators of all vertical radiators. (See Fig. 3.)

The same precaution is also taken for the outside power substations and in front of certain sections of the transmitter buildings such as the large glass-brick section of the transmitter at Vercheres. (See Fig. 4.)

It may be interesting to note that sandbags are not used here but loose sand between wooden supports. This construction is in sections so that damage to one part of the structure will not cause all the sand to pour out, rendering the whole barricade useless. It was learned by experience early in the game that sandbags are not suited to long exposure to Canadian climatic conditions; all the sandbag barricades that were originally installed collapsed within twelve months, due to rotting of the bags.

Protection against sabotage is, of course, only a small part of the measures we have had to take. The situation in Canada with regard to shortage of equipment and difficulties of procurement is just as serious as in the United States, and perhaps even more so, since practically all of the major radio parts and transmitter tubes used in Canada have to be purchased from American manufacturers.

As a contribution towards the solution of the general problem of equipment shortage and as the surest way of insuring the continuity of service, the engineers of the CBC are now concentrating their energies in an extensive conservation program. Realizing that the success of such a program depends primarily on the extent to which every one of its staff is convinced of the fact that no conservation measure is too unimportant to receive his fullest attention, the CBC is taking every possible means to keep its operators, as well as members of other departments, constantly "conservation conscious." This is a most difficult task because, as is generally recognized, there is no other young industry that has been so spoiled as broadcasting in getting everything it wanted with so little consideration to the problem of equipment procurement. Everyone will readily agree as to the necessity of conservation, but from this abstract admission to effective acts of conservation lies a gap which only organized, persistent, and thorough efforts can bridge.

The backbone of this conservation drive is a sort of war-emergency manual which is distributed to all who handle equipment. This manual outlines the facts of the problem and indicates practical ways of meeting it. This has been prepared in loose-leaf form so that sections can be modified or added with ease. This is supplemented by releases from the engineering headquarters designed to keep the interest of the staff in conservation matters constantly alive. The material for these releases is generally taken from news items or from articles in newspapers and magazines which provide some striking examples of shortage difficulties or of particularly interesting ways of meeting them.

As to the contents of this manual, there is nothing that is not already known or cannot be written down by any engineer analyzing all the possible methods of protecting and conserving equipment by careful handling, efficient circuit protection, prevention of abnormal conditions, elimination of unnecessary operation, efficient and economical utilization, and by good maintenance and operating practices.

In the same manual are given full instructions regarding fire protection. Necessary precautions have been established at all plants to protect them against the ordinary peacetime risks of fire, which probably are still, at this time, the gravest risks of destruction which have to be faced.

Since many good papers have already been written on this subject of protection and conservation, it would seem unnecessary to go further into the matter now. A few specific measures, however, have been taken to reduce equipment requirements which may be interesting to note.

An accurate inventory has been made of all CBC facilities, spare parts, expendables, and even of so-called "junk piles" as a preliminary step towards redistribution if necessary. With the number of plants operated by the CBC this is an equivalent, within one organization, of the idea of "pooling of equipment" which is being considered by American broadcasters and under this plan the spares of any one of the CBC stations can be shipped at a moment's notice to any other CBC plant which may be in difficulty.

This idea has been extended even to complete installations. At the Toronto studios, the program and network traffic has so increased as a result of special war productions that its master-control facilities can no longer handle the load. To meet this situation without new equipment arrangements, the CBC engineers are now moving to Toronto a complete modern master-control installation of 8 input, 10 output, and 8 transfer busses of the preset type from their Ottawa studios where it was installed two years ago. At Ottawa it will be necessary to operate with a simplified switching system assembled from units already on hand until radio manufacturers are again in a position to supply new equipment.

To conserve high-quality microphones, restrictions have been made to limit the number of microphones to be used on any one program. This last measure should actually improve the quality of programs since good engineering indicates the use of as few microphones as possible. Similarly, for turntables and reproducers, all high-quality units are used only where the higher performance can actually be appreciated and

they have been replaced with the cheaper types for such work as sound effects, auditions, etc. In addition, a survey has been made of all so-called obsolete equipment, and antiquated amplifiers, which have been discarded on account of high noise level, etc.; when needed, these units will be rejuvenated by minor changes in tube types and circuits.

The possibility of reducing the operating time of transmitters has also been studied but to date the desire for such a reduction has been counteracted by the need of extended hours of operation to provide service to many workers of the war industry who cannot listen at regular hours.

Perhaps the most important contribution that broadcasting could make towards conservation of tubes and equipment would be actually to reduce the power output of broadcast stations. A 20 per cent power reduction might double the life of tubes and yet hardly affect the service to the listener. The CBC engineers are convinced of the advisability of this measure and have already taken active steps towards its application by recommending its adoption to the Canadian Radio Administration. Pending an official decision, the necessary simple modifications to the control and protective circuits have been made at all CBC stations to switch over to reduced-power operation without delay as soon as permission is granted. Tests have shown that many tubes that had to be taken out of service as unable to deliver full power can give many more hours of useful life in operation with reduced-power output.

While still on the subject of maintenance of operations under conditions of war economy, some notes on the personnel problem might be of interest. Out of a total of 180 engineers or technicians, the CBC has already given around 50 to the military services or to the war research, and many more are expected to go. Generally speaking, these have been replaced by men with less experience who were not eligible because of age or physical unfitness. At two studio points, women operators are now employed and so far have been entirely satisfactory for manual broadcast operations where actual knowledge of radio theory is not essential. To counteract the inevitable degradation of operating standards as an inexperienced staff gradually replaces a fully qualified personnel, an extensive educational program has been established to give the necessary theoretical background to the newcomers as well as to refresh the knowledge of the regular men who have been able to remain. These same educational advantages are made available to the office staff in the hope that they may be not only of personal benefit to them but may also result in the formation of a trained reserve which can be drawn on at a later date.

For obvious reasons, the second aspect of the problem, that is, the carrying on of operations during an actual enemy attack, cannot be covered in detail here. At all points the usual routine arrangements have been made with military and civilian defense authorities regarding the shutting down of transmitters and blackouts. In the more exposed locations, in co-operation with civilian and national defense, special facilities have been established to broadcast independently of the main studios the official instructions to the local population and other transmissions that would be necessary during such an attack.

Finally, there is the third aspect of the problem and that is the maintenance or the resumption of essential operations after the partial or complete destruction of regular facilities. This covers measures designed to protect operations in the sense of providing for alternate methods of operation and for stand-by equipment to be used in the case of loss of vital facilities. Because of economic considerations and more particularly because of the impossibility of getting any new equipment, these measures, which have to be taken solely with materials already on hand, had to be restricted to the more essential and important parts of the system in the light of their relative vulnerability. The word "vulnerability" is used here in its broad sense to include not only the possibility of destruction by enemy action and sabotage but also by the normal peacetime risks such as fire. Whatever the cause of destruction, the results would be the same at this time when replacement is virtually impossible.

In addition to the direct measures which have already been mentioned regarding the protection of plants against destruction by fire and sabotage, there are three distinct methods by which the effect of such losses can be minimized should they occur in spite of these precautions. These are the dispersion of facilities, the provision of stand-by or emergency facilities, and finally the prearrangement of facilities and operations in such a way as to allow readily the shifting of operations from one point to another if necessary.

To meet the possibility of destruction of the regular antennas, emergency aerials will be installed at all transmitters. Having already lost one of our aerials in a gale, the 525-foot radiator of CBM near Montreal, the CBC engineers have practical experience in the subject of antenna losses. They have come to the conclusion that a simple structure of the L or T type with 80-foot masts is adequate. On a frequency of 1070 kilocycles, calculations give a field strength of 158 millivolts per kilowatt at a mile and this is enough for emergency operation. Such an antenna costs only $1000 complete. A similar structure with masts of 150 feet would cost twice as much while giving only 15 per cent more radiation. By placing the emergency antenna close to the transmitter building, the question of the emergency transmission line offers no problem.

To protect against the loss of power service some of the CBC plants are already equipped either with two independent electric-power feeds or with a stand-by gas engine. Unfortunately other points have no such power protection but efforts are being made to locate,

on the used-equipment market, odd gasoline engines and generators which might be assembled together to provide at least enough power for operation of these plants out of their driver stages.

This brings us to the important point of low-power operation. Only one of the CBC transmitters uses high-level modulation where low-power operation is not feasible and all other plants either have or will have facilities permitting rapid switching from full power to reduced power out of the driver stages. This provision, which can usually be made with only minor circuit changes and is already a most useful one under normal conditions, may now become a necessity with the present shortage of power tubes becoming more acute each day.

Obviously, emergency antennas, alternate power supplies, and low-power operation are no guarantee against the total loss of the plant, or against serious interruptions of service in a multitude of different ways. The only way to circumvent this eventuality is to have another transmitter which can be put into service in an emergency. Fortunately, such protection is possible at most of the CBC main outlets. In Montreal, there are two CBC stations: CBF on 50 kilowatts and CBM on 5 kilowatts. Similarly, in Toronto there is CBL on 50 kilowatts and CBY on 1 kilowatt, with a directional antenna concentrating the signal on the city. Normally, these stations carry different programs but in an emergency, when program diversity becomes of secondary importance, all essential broadcast services could be shifted to either one of the two stations. As a matter of fact, the service in these cities and also in Vancouver has been further protected by low-power stand-by transmitters of 100 watts installed directly at the studio plants. These transmitters are arranged for operation on either one of the frequencies of the two main transmitters as well as on medium short-wave to be used also as a studio transmitter link in case of failure of the studio transmitter lines. Although these 100-watt stand-bys are not capable of serving the outlying districts covered by the main transmitters, they can provide adequate service at least within the cities concerned which represent more than half of the population served by the regular stations.

These stand-by transmitters have been assembled from old units which were taken out of service from other CBC stations whose power was increased some years ago. The case of the Vancouver stand-by may be interesting. Normally, this is the short-wave station CBRX which is used to provide short-wave broadcast service to sparsely populated areas inside British Columbia which cannot be covered by CBR's broadcast-band transmissions. This short-wave transmitter was originally located with the main transmitter at Lulu Island outside Vancouver. The masts for the short-wave doublet are used at present to support the emergency antenna for the main transmitter and the short-wave transmitter itself has been moved directly to the studios while a new short-wave doublet was installed on the roof of the hotel in which the studio is located. This same antenna is also used as a T aerial for broadcast stand-by service with the short-wave transmitter modified for operations on the frequency of the main transmitter. This transmitter can serve also as a studio transmitter link. The only drawback is, of course, that the regular short-wave service would have to be discontinued in case of an emergency. This, however, is not serious.

At transmitters such as CBA and CBK which are 50-kilowatt stations situated in areas of widely scattered population, 100-watt stand-by transmitters would be useless and the establishment of duplicate high-power stations is out of the question. Fortunately, however, there are on the CBC network a number of privately owned stations of lower power which are dispersed throughout the same area. In case of an emergency, essential official broadcast services could, therefore, be taken over by these stations which are already receiving regular CBC service.

Finally, a few words about the protection of program-production centers. At the Toronto studios, protection measures are only in their initial stage but they are proceeding according to a general plan. In addition to the main studios which are located in a fireproof building, there are two remote permanent auditorium studios as well as a number of other rented halls which are used more or less regularly. With this original dispersion the loss of the main studios would not cause complete loss of service inasmuch as it would be possible to continue on a much reduced scale from the auditorium studios and halls. But this is not sufficient as it is desired to guarantee the restoration of service to practically full normal standards. To accomplish this, it has been decided to install at one of the concert studios small talk studios and control equipment to be used as transmitter booths in case of an emergency. Similarly, at the same point there will be a stand-by master control to handle the program distribution to and from the networks which is normally carried at the main studios. Since the transfer of operations to this emergency point must be done with the minimum loss of time, it will also be necessary to install independent loops to the telephone and telegraph companies for feeds to the transmitters and networks.

While this problem of line and network protection is too involved to be discussed here, the fact should be emphasized that it is very important as well as very complex. It has been found from experience that the various wire circuits to and from a studio plant may actually be all routed through the same telephone exchange, in which case the destruction of this particular exchange may be just as serious as the loss of the studios. To avoid this difficulty, the emergency-studio point should be so located in another part of the city that its loops will follow a route different from that

taken by the regular facilities. Of course, the ideal protection for loops is frequency-modulation links. Unfortunately, these can no longer be procured and the few units which are already on hand have to be saved for locations where loops are not available.

Of course, two small booths and two auditorium

Fig. 5—Some of the special portable equipment to be used by the CBC in the protection of studio operations.

studios would not be sufficient to carry the load of normal production. To take care of this it is planned to originate some programs at outside halls equipped with portable speech-input equipment. This equipment is probably the most important single element of protection for studio operations. At all CBC studio points, all remote gear, amplifiers, microphones, stands, cables, order-wire telephones, sound-effects turntables, portable recorders, and mobile units are to be kept away at all times from main studios and are to

Fig. 6—One of the mobile units of the CBC.

be stored in the safest possible location. This measure will be very inconvenient from an operating standpoint, but on the other hand, no matter what disaster has to be faced, it is hardly likely that both main-studio facilities and the remote gear would be destroyed at the same time.

Fortunately, the CBC already had on hand enough portable equipment to insure this protection at all studios as well as to equip the emergency master control and booths mentioned previously.

This equipment was designed before the visit of the King and Queen of England to take care of the very extensive hookups that were made at that time. Some of these broadcasts, which required as many as 30 operators for a single event, could not be handled with the ordinary portable sets. To meet the situation the CBC engineers designed new equipment: special, 2-channel, 10-microphone, alternating-current—direct-

Fig. 7—The van which is used by the CBC correspondents in England for remote and recording work.

current portable amplifiers; portable master-control units, capable of handling any combination of inputs or outputs; portable order-wire communication sets, etc. (See Fig. 5.) With these units it is possible to set up practically any kind of emergency-control point anywhere that lines are available.

Finally, a word about the CBC mobile units which should play a most important role in any emergency situation.

The corporation has three permanently equipped mobile stations but mobile unit No. 2, which is attached to the Quebec region, is the most complete installation of that type which it operates. (See Fig. 6.)

Fig. 8—Inside view of CBC's mobile unit in England showing recorders and amplifiers.

It is a trailer and car combination with the electric-power plant in the rear compartment of the automobile. The trailer is equipped with two recording channels, two 40-watt transmitters which can operate on either medium short-wave or ultra-high frequencies, also with a push-button master-control position and the necessary audio equipment for the simultaneous broadcasting of two separate feeds. It is also supplied with the usual accessories, microphones, cables, test equipment, packsets, receivers, etc. This unit has actually been used in motion to transmit separate French and English commentaries at the same time. Under normal conditions, transmissions from this unit are excellent, and unless the fact is stated on the air, it is generally quite difficult to distinguish them from an ordinary broadcast.

The most recently built unit, which is now in operation in England, uses a special military van designed to meet the conditions under which it has to operate. (See Figs. 7 and 8.) It has been overseas now for more than two years and has seen actual war service during the height of the blitz over the British Isles, making more than 6000 recordings, in connection with the activities of the Canadian Corps overseas.

As mentioned in the foregoing, all these measures which have been described are pretty obvious and none represents any innovation:

Protection against sabotage, by the erection of fences and barricades, by the provision of floodlighting and armed guards.

Protection of plant by fire instructions and precautions.

Conservation of equipment by efficient utilization, by good maintenance and operations practices, by the rehabilitation of obsolete units, by the elimination of unnecessary operations, and by the reduction of the power of transmitters.

Protection of transmitter operations by emergency antennas, by operations out of the driver stages, by stand-by generators, and by stand-by transmitters of low power.

Protection of studio operations by dispersion of facilities, by the setting up of emergency control points, and by the use of portable equipment and mobile units.

In all these measures and in the many others which have been taken, the engineering difficulties which had to be solved are minor ones, and yet, as every one knows who has been faced with the problem, progress is most difficult. The real problem of the broadcast engineer is, first, to bring about a full and general realization of the seriousness of the situation, and second, to take immediate and effective measures to meet that situation irrespective of the efforts, inconvenience, and constant self-discipline which these may entail. In the face of an emergency which may strike at any time and in any location, preparedness is our first and most important duty.

Appendix

Since this paper was prepared, some months ago, much progress has been made in the execution of the plans already described and a few notes may now be useful to bring the subject matter up to date. Our plans for the conservation of tubes by the readjustment of the operating conditions at transmitters have been given effect and all high-power stations of the CBC have now been operating under reduced voltages following the experimental period which began in May, 1942.

An investigation of the vulnerability of local loops and other wire facilities has shown that extensive protection by the use of radio-frequency links was necessary. After considerable procurement difficulties enough parts have been obtained from used equipment and other sources to undertake the setting up of a number of frequency-modulation and amplitude-modulation links at various strategic points. With these units it is expected that adequate programming service can be maintained in large operating centers independently of normal physical circuits.

But perhaps the most important development in the CBC's war-emergency plans has been in the field of co-operation with military and civilian-defense authorities. With the continually growing realization of the potentialities of broadcasting and its associated networks, these authorities have requested, in certain regions, the use of portions of the CBC network for instructions to broadcast stations and the public generally concerning the silencing of stations, blackouts, and other civilian-defense matters necessary in an emergency.

These important developments and others, particularly in the field of conservation, have in great part been made effective by the work of a special War Emergency Operations Committee which has been set up to study and co-ordinate all phases of the problem.

The Focusing View-Finder Problem in Television Cameras*

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Summary.—**The technical excellence of a television program may frequently depend on the characteristics of the view finder used in the television camera. Conditions peculiar to television make it desirable that television-camera view finders be of the focusing type. The requirements of an ideal view finder of this type are discussed. During the past ten years a number of view-finder arrangements have been investigated in connection with the development of television cameras. Several of these are described and their relative merits indicated.**

Introduction

ONE OF the most essential elements in a television camera is the view finder. On its characteristics may depend the technical excellence of the television program. The desirability of minimizing operating personnel and the necessity for keeping a camera in practically continuous operation during television programs of one or two hours make it necessary that the view finder be of the focusing type. Such a view finder not only provides a view of the scene which is included in the field of the camera but also indicates when the lens is properly focused on the desired scene.

During the past ten years a number of focusing view finders were investigated to determine their suitability for use in television cameras. Brief mention of some of these arrangements has already been made in the technical literature on television equipment. Practical operating experience with several view finders both in the studio and outdoors has established certain requirements which an ideal view finder should meet. It is the purpose of this paper to discuss these requirements; to describe briefly several of the view-finder arrangements which have been investigated, and to indicate their relative merits.

Requirements of an Ideal Focusing View Finder for Television Cameras

The requirements of an ideal view finder may be stated as follows:

1. It should at all times accurately indicate when the camera is in focus on the desired scene or object.

2. It should not only define that portion of the scene which is being converted into the television image but also should reproduce a sufficient portion of the scene outside the camera field so that the cameraman will know in advance what the television picture will include if he pans the camera in any direction.

3. It should provide an erect image which is correct left to right and of sufficient size and brightness to minimize eyestrain.

4. It should not unduly complicate the procedure of interchanging camera lenses or pickup tubes.

5. For portable pickup work the view finder should not contribute substantially to the size and weight of the camera.

It will be noted that the first three of these requirements deal with performance whereas the last two are concerned primarily with operating convenience.

In order to appreciate the significance of these requirements it is of interest to discuss them in connection with the two general groups of view finders into which the several individual view finders are subsequently classified. For the purpose of this discussion the first group will consist of those view finders which derive the view-finder image either directly or indirectly from the camera lens. The second group includes those which make use of a separate optical system for producing the view-finder image.

Requirement Number 1

Requirement 1 specifies that the view finder should at all times accurately indicate when the camera is "in focus" on the desired scene or object. Practical operating experience has shown that in respect to this requirement it is desirable that the cameraman be aware of a degradation in picture detail due to improper focus before the loss in resolution is apparent to the television audience. The view finders in group 1 have several limitations with respect to this requirement. When the scene which is being televised is sufficiently illuminated so that the camera lens can be stopped down to provide greater depth of focus the view finders in this group do not provide an accurate focus indication since the view-finder image has the same depth of focus as the camera image. In other words, no apparent change in detail is observed by the cameraman as the lens is moved back and forth through an appreciable range. This limitation may not be particularly apparent to the television audience from the standpoint of picture detail but is likely to be disturbing for another reason. Under this condition the cameraman has a tendency to move the camera lens back and forth to determine by approximation the center of the range over which no effect on picture detail is observed and thus establish the "in-focus" position of the lens. As the lens is moved back and forth, the area included in the television image changes in such a manner that the sides of the picture appear to move in and out; an effect which is disturbing to most observers.

Another result of this inaccurate focus indication is encountered when the camera is used under conditions

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† RCA Manufacturing Company, Camden, New Jersey.

where the illumination may vary suddenly through a fairly wide range. Such conditions are frequently encountered in outdoor pickup of sporting events or spot news, etc. If the lens is stopped down and the camera is inaccurately focused on a scene in bright sunlight and the sun subsequently goes behind a cloud, making it necessary to increase the lens aperture, the camera will be out of focus. The focusing readjustment which is then required would have been avoided if the view finder had met requirement 1.

The view finders in group number 2 can all be made to meet requirement 1 provided they are constructed with sufficient mechanical rigidity to maintain, at all times, the proper alignment between the optical systems for the view finder and pickup tube.

Requirement Number 2

Requirement 2 states that the view finder should always provide an image of and accurately define that portion of the scene which is being converted into the television picture and should also provide a view of at least a small part of the scene on each side of the television-picture area. Unless the first part of this requirement is fulfilled the cameraman may not know, for example, whether or not an individual's head is in the picture. The second half of this requirement gives the cameraman an indication of what will be included in the picture if he pans the camera in any direction. The need for this information may depend to some extent on whether the camera is being used in the studio or outdoors. From one standpoint, there is less need for this additional view-finder-image area in the studio because studio programs are usually rehearsed several times. On the other hand, in studios several sets are frequently used in a limited space so that a camera can be changed quickly from one scene to another. This makes it necessary for the cameraman to know what is included in a small area outside the field of his camera so that he does not inadvertently include an edge of an undesired set in the picture. If the view finder does not provide an image of this additional area it is frequently necessary for the cameraman to move his head sufficiently so that he can look along one side of the camera to determine the effect of panning the camera in a desired direction. Not only is this inconvenient but when the cameraman looks around the camera at the brighter scene and then again looks at the image in the view finder it is necessary for his eyes to readjust themselves to the difference in the light intensity. In outdoor pickup work such as sporting events, where the action is unpredictable, if the cameraman looks around one side of the camera he may lose the action altogether before he has time to again look into the view finder.

In general, the view finders in group 1 do not meet requirement 2 since the view-finder image which they provide is obtained from the camera lens and covers the same picture area as the television image.

The view finders in group 2 make use of a separate optical system and, therefore, can be made to provide a view of some of the scene around the area which is converted into the television image. Such view finders are, of course, provided with hairlines on the viewing screen or some other expedient which indicates the actual area of the scene which is included in the television picture. It is essential that the view finders in this group be provided with some means which will correct for parallax between the two optical systems.

Requirement Number 3

The ideal view-finder requirement 3 is met if the view finder provides an erect image which is correct left to right and of sufficient size and brightness to minimize eyestrain. A difference of opinion may exist as to the necessity of having the view-finder image erect and correct left to right. If the cameraman has received considerable training with cameras providing images which are inverted and reversed left to right, such a view finder is undoubtedly satisfactory. He will then have developed the proper co-ordination between the image he sees in the view finder and the direction in which he must move the camera to produce a desired effect. On the other hand, in a new field, such as television, where it will be necessary to start with relatively untrained personnel, it is felt that the corrected view-finder image will be more satisfactory.

With respect to the other stipulations in requirement 3, a view-finder image at least 3 by 4 inches at a viewing distance of 12 inches has been considered to be satisfactory. The image should be as bright as possible. No difficulty has yet been encountered from having the view-finder image too bright. The ability of a specific view-finder arrangement to meet requirement 3 is basically determined by the amount of light which it supplies to produce the optical image since, if sufficient light is available, an optical system can be used to increase the image size and reverse it in either or both directions.

The problem of providing sufficient light to produce a satisfactory view-finder image is becoming more difficult as the sensitivity of camera pickup tubes is increased. This limitation may ultimately make it necessary to resort to a highly complicated view-finder arrangement which will be described later.

Requirement Number 4

This requirement is concerned with the effect of the view finder on the ease of interchanging either pickup tubes or lenses. Since emergencies may arise which make it necessary to change pickup tubes and since it is frequently desirable to change to a different focal-length camera lens, it is essential that these changes be made in the shortest time and with the least inconvenience.

This requirement is met to the greatest extent by

the view finders in group 1 since they derive the view-finder image from the camera lens. The view finders in group 2, which use a separate optical system for producing the view-finder image, all contain some element which must be adjusted to provide satisfactory optical alignment between the two optical systems when pickup tubes are changed. Up to the present time it has been impracticable to manufacture pickup tubes with sufficiently close tolerance on the position of the mosaics and other elements of the tubes to make them optically interchangeable. Some adjustment, therefore, is necessary so that the view-finder image and the image on the pickup tube are "in focus" simultaneously. It is possible to shift the position of the pickup tube in a camera to obtain satisfactory optical alignment between the two optical systems. The size and weight of the pickup tube with its deflecting yoke, however, make it much more practical to move a ground-glass screen or some other element in the view finder to provide the necessary alignment between the two opical systems.

No serious complications are encountered in interchanging lenses of different focal lengths in cameras employing the view finders in group 1 since only the camera lens is changed.

The additional lens required with the dual-lens view-finder arrangements in group 2 make the problem of interchanging lenses somewhat more difficult. This is particularly true where the lenses are large and heavy such as those having focal lengths of 20 inches or more and apertures of the order of $f/4.5$.

Requirement Number 5

Requirement 5 is based on the desirability of keeping the size and weight of television cameras for portable pickup work at a minimum. Studio cameras are usually semipermanently mounted on large dollies similar to those used in motion-picture work and the size and weight of the television camera for studio work is, therefore, not a primary consideration. Portable television cameras, however, are used on conventional tripods and are set up and subsequently taken down at each pickup location. It is, therefore, desirable to keep the size and weight of cameras for portable pickup work at a minimum. In some cases a sacrifice in view-finder performance has been made to permit a reduction in the size and weight of the camera. Some portable cameras which employ one of the more complicated view finders are constructed so that the camera can be separated into two units. This construction not only makes the camera more portable but also makes it possible to mount the two parts separately on the tripod.

Since the view finders in group 1 require less parts, occupy less space, and contribute less weight, they are more acceptable from the standpoint of requirement 5 than those in group 2.

Description of Individual View Finders

The following is a list of the view finders which will be described.

1. Mirror arrangement for observing the optical image on the mosaic of the pickup tube.
2. Semisilvered mirror arrangement for utilizing the camera lens to produce an optical image on a ground-glass viewing screen.
3. Kinescope or electronic view finder.
4. Kinescope or electronic view finder with remote focusing control.
5. Split-image view finder as used in the Contax and similar cameras.
6. Duplicate-lens view finder as used in the Rolliflex camera.
7. Combination duplicate lens and kinescope view-finder.

The first four view finders in this list derive the view-finder image either directly or indirectly from the camera lens and are those which were previously classified as the group 1 view finders. View finders 5, 6, and 7 are the group 2 view finders and obtain the view-finder image from a separate optical system. For the sake of simplicity, the diagrams which will be used to illustrate the several view finders will not show any means either for magnifying the optical image or for correcting it in the vertical and horizontal directions. It is apparent, that if sufficient light is available, lens and mirror arrangements can be used to accomplish any of these results. The means for correcting for parallax is likewise omitted from the diagrams of the group 2 view finders. Although the iconoscope is shown as the pickup tube in each of the diagrams it is obvious that the orthicon or any other type of pickup tube may be used.

Mirror Arrangement for Viewing the Optical Image on the Mosaic of the Pickup Tube

The original iconoscope camera view-finder arrangement is illustrated by the diagram in Fig. 1. With this view finder the cameraman, through the use of mirror A, observes on the mosaic B the optical image which is produced by the camera lens C. The shape of the glass envelope of the pickup tube is usually such that only a portion of the image on the mosaic can be observed through the use of this system. The mosaics of the more recent pickup tubes have very poor light-reflecting properties and the optical image produced on the mosaic is, therefore, unsatisfactory from the brightness standpoint. The chief advantage of this arrangement is its simplicity. It requires a minimum of equipment since it makes use of only the camera lens and does not employ a separate viewing screen. No special adjustments are necessary when changing either the camera lens or the pickup tube. It has, however, all the limitations previously mentioned in connection with the group 1 view finders.

Semisilvered Mirror Arrangement Utilizing the Camera Lens to Produce an Optical Image on a Ground-Glass Viewing Screen

The diagram in Fig. 2 illustrates the view finder system, which makes use of a semisilvered mirror A to reflect some of the light transmitted by the lens B. This light is again reflected by the mirror C to produce an optical image on the ground-glass viewing screen D. In the experimental work on this arrangement, mirrors were used in which the reflected light varied from 15 to 40 per cent. Since the total light reflected from the front-surfaced mirror A is a comparatively small percentage of the light passing through the mirror, the light reflected from the back surface of the mirror may be a fairly large percentage of the total reflected light. It is, therefore, necessary to use either a very thin

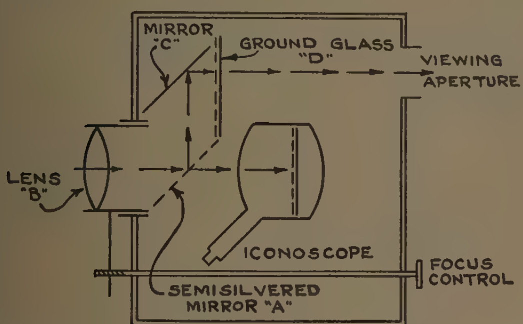

Fig. 1—Mirror arrangement for viewing the optical image on the mosaic of the pickup tube.

mirror or else have the back surface of the mirror coated with a nonreflecting film; otherwise the light reflected from the back surface produces an image which is sufficiently displaced from the front-surface image to reduce the effective resolution of the view finder to a point where it is definitely unsatisfactory.

The chief advantage to be found in this view finder likewise lies in its relative simplicity. With respect to the arrangement shown in Fig. 1, it has the advantages of giving a somewhat brighter image and also will provide a view of the scene whose area is greater than that included in the field of the camera.

The most serious disadvantage of this view-finder arrangement is that it robs light from the mosaic of the pickup tube and therefore decreases the effective light sensitivity of the system. Although it meets requirement 2 it has the other limitations of the group 1 view finders. Since a separate ground-glass viewing screen is used with this arrangement it is necessary to adjust the position of the viewing screen when changing pickup tubes so that the viewing screen is the same distance from the optical center of the lens as the mosaic of the pickup tube. This view-finder arrangement also imposes a limitation on the shortness of the focal length of the camera lens which can be used.

Kinescope or Electronic View Finder

This view-finder arrangement is obtained by incorporating in the camera a kinescope on which is reproduced the television image. It is illustrated by the diagram in Fig. 3.

The chief advantage of this view-finder system is

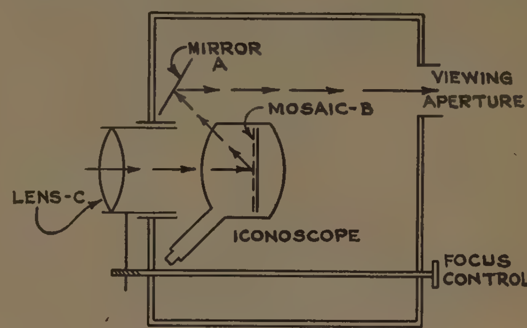

Fig. 2—Semisilvered-mirror view-finder arrangement.

that the relative brightness of the view-finder image does not diminish as the sensitivity of the pickup tube is increased. The brightness of the Kinescope view-finder image is determined primarily by the characteristics of the kinescope which is used and the operating voltages which are employed. It, like the view-finder arrangements illustrated in Figs. 1 and 2, does not necessitate any view-finder adjustments when either pickup tubes or camera lenses are interchanged and no correction for parallax is required.

In addition to the several limitations discussed in connection with the group 1 view finders the kinescope

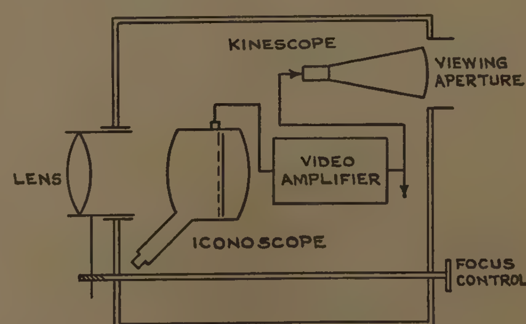

Fig. 3—Kinescope or electronic view finder.

type of view finder has the further restriction that the sharpness of the view-finder image is dependent on the resolution of that portion of the television system which it includes. It is, therefore, necessary that satisfactory electrical focus of the kinescope be maintained for this view finder to function satisfactorily. The

space required in a camera to house this type of view finder is relatively large. The several thousand volts which are used as anode supply for the kinescope present a problem in providing a satisfactory camera cable. If this camera-cable problem is avoided by incorporating a voltage-supply unit in the camera a corresponding increase in the size and weight of the camera results.

Kinescope or Electronic View Finder with Remote-Focusing Control

In the kinescope view-finder arrangement just described, a television monitoring unit with its kinescope

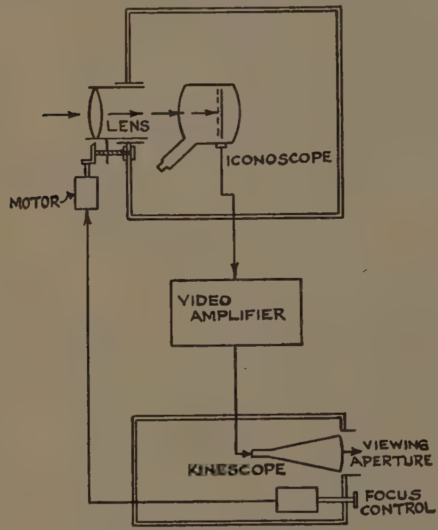

Fig. 4—Kinescope or electronic view finder with remote focusing control.

is in effect moved from its normal location so that it can be associated directly with the focusing control in the camera. In the remote-control form of the kinescope view finder the physical location of the parts is reversed and a remote camera-focusing control is provided that can be used at the normal location of the television monitoring unit. The diagram in Fig. 4 illustrates this arrangement. As indicated in the diagram, the remote control of focus is accomplished through the use of Selsyn motors.

The chief advantage of this view-finder system lies in the fact that it permits a camera which is small in size and light in weight. This is especially desirable in portable pickup work. It makes possible a camera which is particularly suitable for locations which are inaccessible to a cameraman. It also provides the advantages which have been discussed in connection with the previous kinescope view finder. With the remote-focusing arrangement the only view-finder equipment which must be housed in the camera is the small Selsyn motor. A wire-frame view finder mounted on the side of the camera is used by the cameraman to keep the camera trained on the desired scene. The focusing is done by a control operator at the monitoring unit.

In addition to the deficiencies of the kinescope view finder illustrated by Fig. 3, this arrangement has the further limitation that a fairly high degree of coordination is required between the man who is panning the camera and the man at the remote point who is operating the focusing control. When the focusing and panning are done by the same individual he subconsciously starts to adjust the focusing control in the proper direction to correct for any change in distance between the camera and the desired scene.

Split-Image View Finder as Used in the Contax and Similar Cameras

The diagram in Fig. 5 illustrates this type of view finder. It utilizes an optical system which is actuated by the focusing control simultaneously with the camera lens and produces two optical images which are accurately superimposed when the camera lens is in focus on a desired object or scene. The two images are displaced with respect to each other when the focusing control has not been properly adjusted. In a view finder of this type which was investigated the condition of focus could be accurately determined only in a small area in the center of the picture. Another limitation of this particular view finder was that when using long focal-length lenses the actual size of an object in

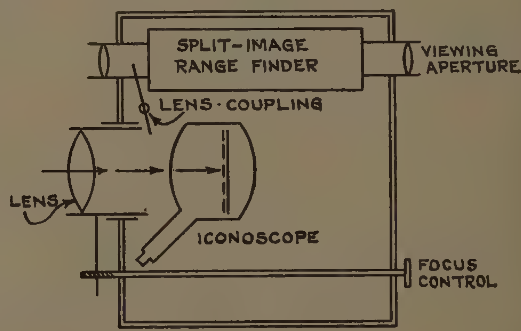

Fig. 5—Split-image view finder.

the view finder remained the same as when a short focal-length lens was used. A hairline indicator was provided to indicate the smaller field covered by the longer focal-length lens. An adjustment is required with this type of view finder when interchanging pickup tubes so that the optical system of the view finder is adjusted to compensate for variations in the position of the mosaic in different pickup tubes.

Duplicate-Lens View Finder as Used in the Rolliflex Camera

As shown in Fig. 6, an auxiliary lens *A*, which has the same focal length as the camera lens *B*, is used to produce on the ground glass *C* an optical image which

corresponds to the optical image on the mosaic D of the pickup tube. The position of the ground glass C, with respect to the optical center of the lens A, must always correspond to the position of the mosaic D with respect to the lens B. The two lenses must be matched accurately for focal length. To facilitate interchanging lenses of different focal lengths each pair of lenses are usually assembled on a single mounting plate. This view-finder system provides an image of a portion of the area outside that covered by the field of the camera. A view finder of this type provides a very accurate indication of focus under all conditions since the view-finder lens can be kept wide open when the camera lens is stopped down. Since a fast lens is normally used to provide the view-finder image the brightness of this image has been relatively satisfactory. The increased sensitivity of pickup tubes, however, is causing the image brightness obtained from this view-finder system to decrease to the point where it no longer will be satisfactory. Some system for parallax correction is required with this type of view finder. The amount of correction which is necessary is generally determined by the maximum diameter of the lenses supplied with the camera.

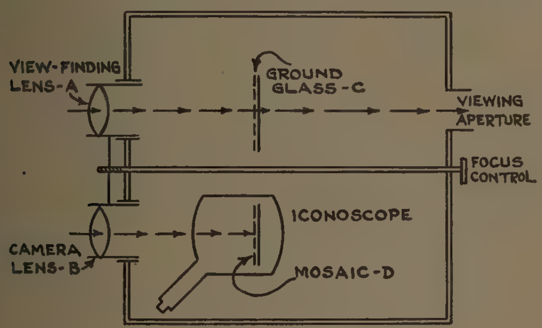

Fig. 6—Duplicate-lens view finder.

The inability of this view finder to meet the ideal view-finder requirements is found in connection with requirements 4 and 5. Since a separate lens is used to produce an optical image on a ground-glass screen, the position of this screen must be adjusted to correspond to that of the pickup-tube mosaic whenever pickup tubes are interchanged. Since the longer focal-length lenses (20-inch, $f/4.5$ lenses are frequently used) are large and heavy, the additional lens required for this view finder not only makes the problem of interchanging lenses more difficult but materially increases the over-all size and weight of the camera.

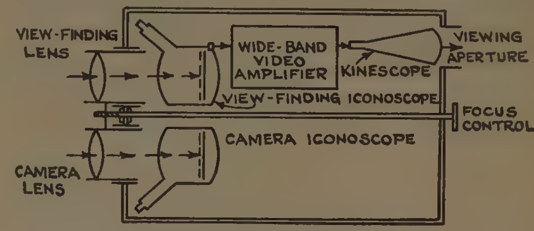

Fig. 7—Combination duplicate-lens and kinescope view finder.

Combination Duplicate-Lens and Kinescope View Finder

It has previously been pointed out that as the sensitivity of the television pickup tube is increased a corresponding decrease occurs in the relative brightness of the image in an optical view finder. At present, when the maximum sensitivity of the orthicon pickup tube is utilized, the image brightness obtained from an optical view finder, such as the duplicate-lens arrangement previously described, is on the verge of being unsatisfactory. With the kinescope type of view finder any increase in the sensitivity of the pickup tube is automatically compensated insofar as the brightness of the view-finder image is concerned. The types of kinescope view finders which have been described, however, do not meet performance requirements 1 and 2. If a further improvement is made in the sensitivity of television pickup tubes, it may be necessary to use a view finder of the type illustrated in Fig. 7.

In this diagram it will be noted that two pickup

TABLE I

View Finders / Ideal View-Finder Requirements	No. 1 Mirror Arrangement for Observing the Optical Image on the Mosaic of the Pickup Tube	No. 2 Semisilvered Mirror Arrangement Utilizing Camera Lens to Produce Image on Viewing Screen	No. 3 Kinescope or Electronic View Finder	No. 4 Kinescope View Finder with Remote-Focus Control	No. 5 Split-Image View Finder	No. 6 Duplicate-Lens View Finder	No. 7 Combination Duplicate-Lens and Kinescope View Finder
No. 1 Provides accurate indication of focus under all conditions.	No	No	No	No	Questionable	Yes	Yes
No. 2 Accurately defines scene in television picture and gives view of some additional area.	No	Yes	No	No	Yes	Yes	Yes
No. 3 Provides image of satisfactory size and brightness.	No	No	Yes	Yes	Questionable	Yes at Present	Yes
No. 4 No special adjustments required when pickup tubes or lenses are interchanged.	Yes	No	Yes	Yes	No	No	No
No. 5 Does not require a serious increase in the size and weight of the camera.	Yes	Yes	No	Yes	Yes	No	No

tubes are used with a pair of duplicate lenses. Associated with the camera pickup tube are the normal television amplifier and deflection circuits. The amplifier used with the view-finder pickup tube is designed to pass a wider frequency band than is normally required by the television system. The increase in resolution, which the wider frequency band permits, enables this view finder to provide a more accurate indication of focus than could be obtained from the previous kinescope view finders. Since a separate view-finder lens is employed it can always be used at its maximum aperture even though the camera lens is stopped down, and thus provide at all times an accurate indication of the proper focus adjustment. The deflection circuits for the view-finder pickup tube are so arranged that a slightly greater area of the scene is scanned than is the case with the camera pickup tube.

The deficiencies of this view finder from the standpoint of the ideal view finder are in respect to the requirements 4 and 5 which deal primarily with operating convenience. With reference to requirement 4, when pickup tubes are interchanged, the position of one of the pickup tubes must be adjusted so that the mosaics of the two tubes are the same distance from their respective lenses. The electrical focus of both the view-finder pickup tube and kinescope must be kept in proper adjustment for this view finder to function satisfactorily. The extra equipment required for this type of view finder materially increases the size and weight of a television camera.

Comparison of the Individual View Finders

Table I shows the ideal view-finder requirements that are met by the several view finders which have been described. The wording used in the table for each of the requirements is such that a "yes" in the column beneath a given view finder indicates that it meets the specified requirements.

Conclusions

It is apparent that none of the view finders which have been described meet all the requirements of an ideal view finder. The relative importance of some of the requirements is determined to a considerable extent by whether the camera is intended for studio or outdoor pickup work. In general, the duplicate-lens type of view finder has given the most satisfactory results. If it is desired to keep the size and weight of the camera as near the minimum as possible, the kinescope view finder with remote-focusing control is a practical arrangement. A substantial increase in the sensitivity of television pickup tubes will result in more consideration being given to the several types of kinescope view finders.

In this discussion no reference has been made to the relative cost of the various view-finder arrangements. For the time being, at least, the cost of television pickup equipment has been considered to be of secondary importance to performance and operating convenience.

Acknowledgment

The writer wishes to acknowledge the individual and co-operative efforts of numerous Radio Corporation of America and National Broadcasting Company engineers who have contributed to the solution of the view-finder problem.

Mercury Lighting for Television Studios*

H. A. BREEDING†, NONMEMBER, I.R.E.

***Summary.*—This paper includes a brief history of the use of water-cooled Mazda H lamps, a light that is cooler than noon sunlight, for television studio lighting, with a detailed description of an installation of remote-controlled floodlights in the General Electric Television Broadcasting Studio WRGB at Schenectady, New York.**

Results are shown by photographs of the line-monitor tube picture when the illumination of the set is provided by mercury lamps. Lamp performance is discussed and data on light maintenance presented.

The New York World's Fair Installation

General Electric's experiment with water-cooled mercury lamps for television studio lighting began at the New York World's Fair in 1939 and finally culminated in a complete installation in the new modern studios of WRGB at Schenectady in the fall of 1941.

The "House of Magic" television installation made use of two banks of three A-H6 1000-watt water-cooled H type Mazda lamps.[1] These were operated from a 3-phase source of power stepped up from 120 volts through high-reactance transformers connected in wye on both primary and secondary.

The three lamps in each luminaire were spaced along the focal axis of the reflectors and connected in series to the city water system and throttled to take about 4 quarts of water per minute. The water circuit was electrically interlocked with the power supply so that without water the lamps could not be started.

The trough-type floodlights were mounted in a

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† Lighting Division, General Electric Company, Schenectady, New York.

[1] E. B. Noel and R. E. Farnham, "A water-cooled quartz mercury arc," *Jour. Soc. Mot. Pic. Eng.*, vol. 31, pp. 221–239; September, 1938.

fixed position forward of and to right and left above a stage about 6 by 8 feet approximately 8 feet high.

Other Experimental Installations of these Lamps

In experimental station W2XB four portable floor-lamp units were devised from 18-inch Miller-etched Alzak-finished concentrating reflectors. Each of these floods likewise used three lamps, but the grouping was about a horizontal line through the focal point of the reflectors with the various lamps about $1\frac{1}{2}$ inches apart on the sides of an equilateral triangle. These floods were supplemented by groups of eight 500-watt reflector flood lamps mounted on portable wooden frames.

A single water-cooled unit of this same type was used in the General Engineering Laboratory at Schenectady for the lighting of experimental subjects in connection with general television developments. All of these devices were mounted on standard motion-picture-studio tripods with an extra telescopic rod for vertical adjustment so that a maximum height of approximately 9 feet could be obtained. In actual practice the height of the devices was seldom changed during any show because of the mechanical difficulty involved.

This type of lighting was recognized as a temporary expedient, but due to the limited headroom no overhead lighting could be provided in the experimental studio. The desirability of a lighting system which would provide a general exposure level at any point in the studio with a minimum of physical effort and equipment was soon apparent, and, coupled with the simplification of studio operation to be expected by removing equipment from the floor, provided the necessary impetus for developing the present ceiling-mounted design.

The first experimental models of the ceiling-mounted units were manufactured for the Columbia Broadcasting System in the fall of 1940. Columbia purchased three of these units, and a fourth was made as a sample for experimental work and testing. The general idea of the first ceiling devices was the same as the design used at present in WRGB, except for the minor changes and refinements that come with building of the second lot of any new device. The reflector was an etched Alzak-finished aluminum trough generally parabolic in shape. The front-door glass was Peblex diffusing glass and the opening was approximately 21 by 33 inches. A motor for rotating the device in the horizontal plane was installed in a canopy mounted against the ceiling and a second motor was mounted inside the reflector housing to rotate the device vertically. Three lamps were spaced along the axis of the paraboloidal trough reflector. The lamps remain in a horizontal plane while the reflector is elevated or depressed. This is a necessary precaution with this type of lamp. The power supply and water feed are brought in through flexible hoses from the canopy at the top into the reflector housing and no slip rings are used. The "elevating" and "rotating" motors are operated from a remote push-button station. The first devices could be rotated through one complete turn horizontally and could be elevated through 90 degrees. In the WRGB installation, the arrangement for horizontal rotation remained as before, but the vertical rotation angle was extended to 180 degrees.

A solenoid valve and a flow switch for interlocking the electrical and water circuits are also mounted in the canopy. The flow switch also acts as a check valve to prevent backflow of water from the discharge line in case of water-jacket rupture. Power cannot be supplied to the lamps unless water is flowing, and if a jacket rupture takes place, water is cut off on both the supply and discharge sides of the unit. A door switch in the same interlock circuit prevents servicing the lamps with power on.

The WRGB Installation

General Proposals

Late in December, 1940, it was decided to proceed with lighting WRGB's new station with ceiling-mounted units supplemented by the four tripod-mounted floor lamps which were to be moved from the old studio to the new. The new studio is 42 by 70 feet, with approximately 18 feet ceiling height between beams. The clear headspace for scenery and microphone booms is approximately 14 feet.

Fig. 1—General studio view.

The piping and conduit run to each luminaire was made to a special ceiling plate fastened on a 30-inch square plank base bolted to the ceiling before the floodlights were mounted. It was originally estimated that the lamps should be spaced on centers to allow about 100 square feet per luminaire, but the final layout in WRGB studio is staggered on rows $9\frac{1}{2}$ feet apart across the building and $6\frac{1}{4}$ feet apart along the building. The average space per unit, therefore, is approximately 120 square feet. In the studio there will

finally be, according to present plans, 19 luminaires, of which 12 are at present installed and in operation. Figs 1, 2, 3, and 4 show the general form and construction of these devices.

Transformer-Room Installation

To conserve space, remove heat from the studio, and maintain the noise level at low values, it was decided to locate the transformer room in the basement

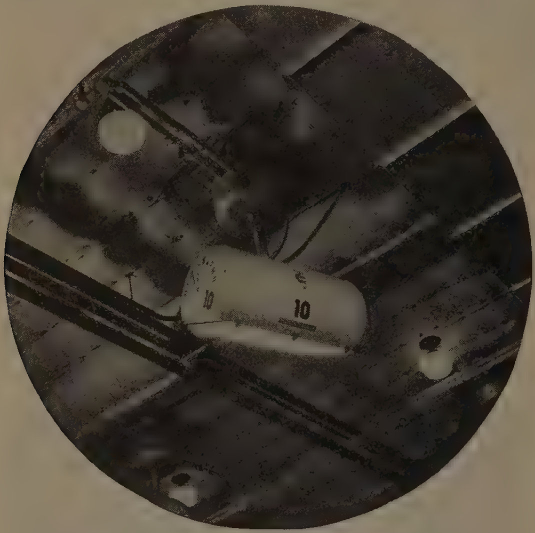

Fig. 2—Close-up of portion of ceiling in television studio in WRGB.

of the studio. A $3\frac{1}{2}$-inch incoming-power conduit was fed into the transformer room from the front of the building. A corner of the transformer room is shown in Fig. 5. Power from the service switch is distributed

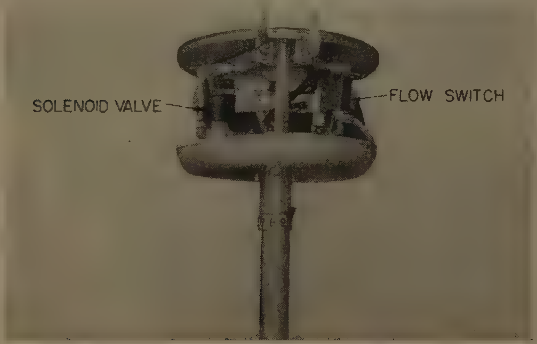

Fig. 3—L-71 with door open showing elevating motor.

through a Flex-a-power distribution system with a 30-ampere disconnect switch to the primary of each control relay. These switches are mounted at about head height and can easily be reached by an operator from the floor. A 4-pole, 13.5-ampere relay operated from a control desk in the studio is mounted on the same pipe framework which supports individual single-phase high-power-factor transformers feeding each lamp. The transformers are connected delta on the primary and wye on the secondary. Primary taps at 208/220/230/240 volts are provided, and the 220-volt tap is used in this case. The transformers have a capacitor for high-power-factor maintenance built directly into them, and in order to keep the noise at a low level,

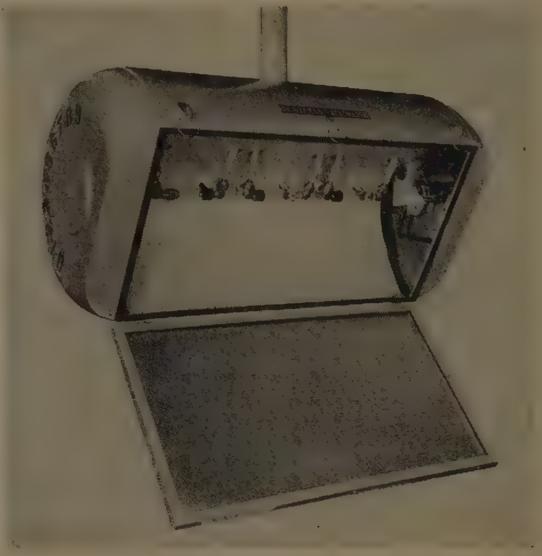

Fig. 4—L-71 showing detail of assembly in canopy.

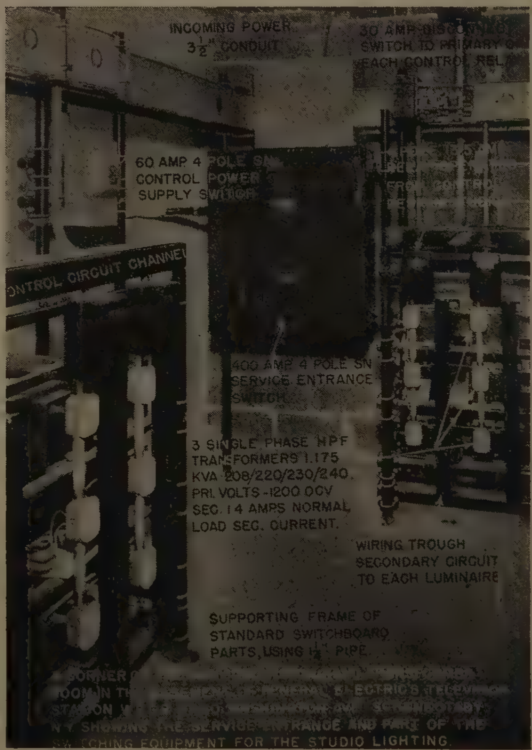

Fig. 5—Transformer room.

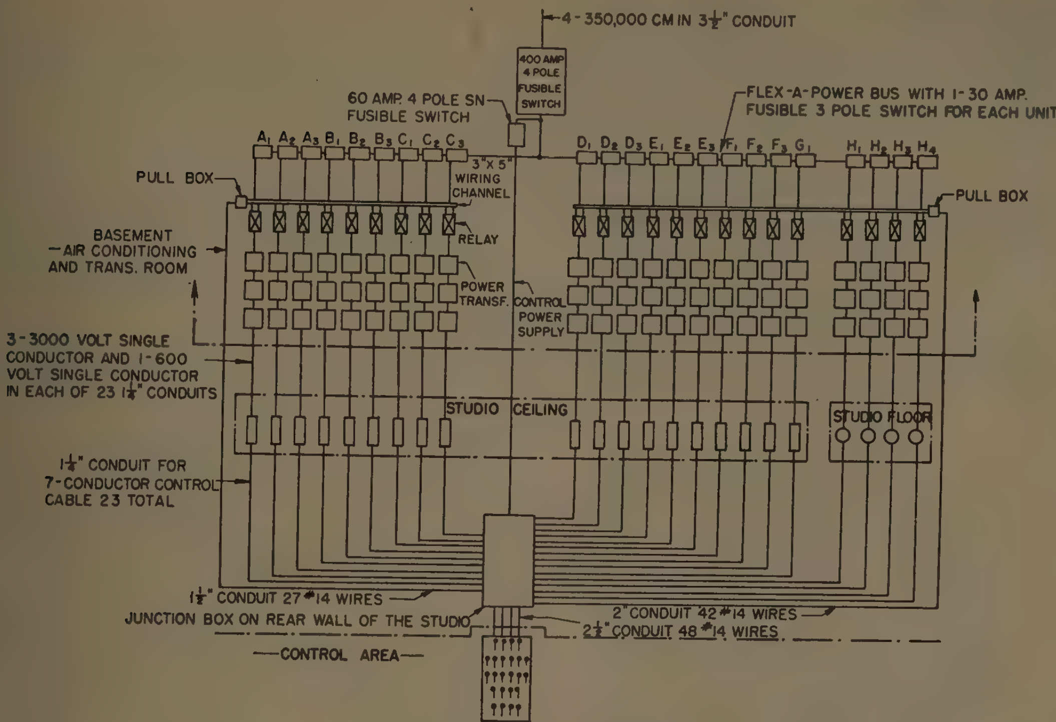

FIG. 6—Master system wiring diagram.

the capacitor and core are imbedded in a silica-loaded compound and the whole device enclosed in a sheet-steel housing. The noise level of the installation is very low, noticeable noises being those of contactor operation and some contactor hum.

System Wiring

A master diagram of the system is shown in Fig. 6. High-voltage conduit runs go directly from the transformer room in the basement to each individual luminaire on the ceiling. Three No. 10 solid, 3000-volt, $\frac{6}{64}$-inch varnished-cambric single conductors with single-braid insulation and one single-conductor No. 14 rubber-insulated, 600-volt, National Electric Code wire with white finish are run in each conduit. These conduits terminate in a high-voltage junction box in the canopy of the luminaire. A low-voltage junction box is also provided in each canopy for control wiring from the terminal board below the light bridge which is mounted on the rear wall of the studio as shown in Fig. 7.

A 24-connection terminal board for the control circuits to each floodlight is provided in the large junction box just below the light bridge. Each terminal board is fed from a separate fused circuit supplied through the lighting console on the light bridge. Mains protection for the control-circuit power is provided by the two air circuit breakers mounted on top of the lighting console.

The control-conduit installation is suspended from the ceiling beams and is shown in Fig. 2. The high-voltage runs were made before the rock-wool insulating blanket was applied to the studio walls and so are

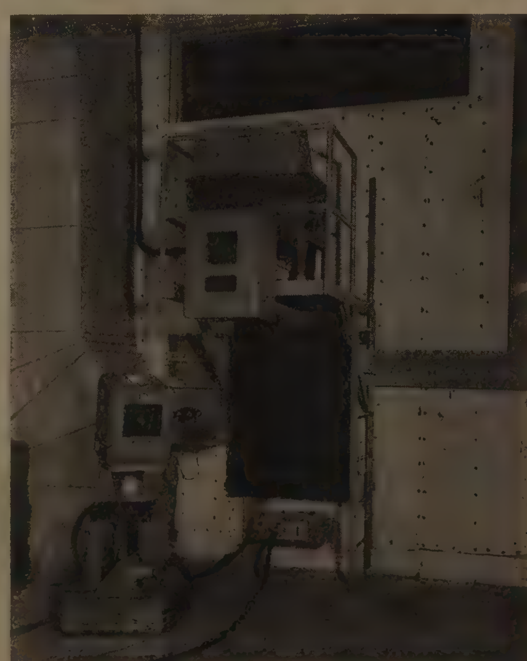

FIG. 7—Rear wall of studio showing light bridge.

hidden except near the connections to each floodlight.

The wiring for each individual floodlight circuit is the same as shown in Fig. 8.

On the lighting console (Fig. 9) the circuits can be individually operated and an individual telephone-

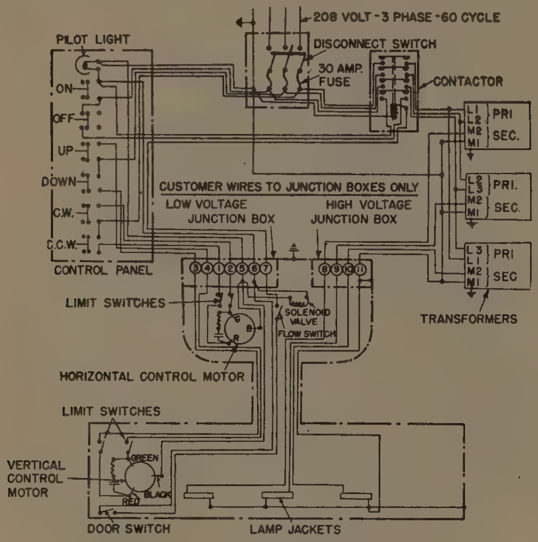

FIG. 8—Unit connection diagram.

type key is provided for the turn-on and turn-off function, another for the elevation motor, and a third for the horizontal-rotation motor. Each control circuit is individually fused by a cartridge-type fuse near the bottom of the console. A pilot light is provided which indicates when the control relay in the transformer room is closed.

Water Circuits

Copper tubing is used throughout for permanence and quiet operation. All pipes are antisweat lagged which also reduces the noise level greatly. A globe valve is supplied for shutoff at each floodlight. A gate valve at waist height above the studio floor in the main riser is used for cutoff and for throttling to the proper head for the system.

The main riser is $1\frac{1}{2}$-inch tubing which branches into two $1\frac{1}{4}$-inch headers. These headers branch into $\frac{3}{4}$-inch runs feeding 4 ceiling plates in parallel in each of 4 bays and 3 in the fifth bay. Of these only the first 12 are now used. One-half inch connections to the floodlights are through unions inside the canopy which encloses the ceiling plate and other equipment mentioned above.

The discharge lines are pitched downward from the unit connection to the 4-inch building vent pipe at 1/8-inch per foot continuous drop. Vent valves were originally supplied at the highest point in each discharge line to vent air bubbles from the system. Difficulty with leaking vents has led to discontinuation of most of them now.

The system uses approximately $1\frac{1}{2}$ gallons of water per unit per minute or about 16,000 gallons of water per week for 15 hours of operation.

TABLE I

LAMP DATA
1000-Watt A-H6 Water-Cooled Mazda H Lamp

Watts (lamp only)		1,000
Operating current (amperes)		1.4
Operating voltage (volts)		840
Approximate initial lumens		65,000
Bulb		
Material	Quartz	
Finish	Clear	
Approximate diameter (inside)	2 millimeters	
Approximate diameter (outside)	6 millimeters	
Approximate length of light source[1]	25 millimeters	
Life[2]	75 hours	
Burning position	Horizontal	
Number of electrodes	2	

[1] Distance between electrode tips
[2] Average lamp laboratory life when operated 25 minutes on and 5 minutes off.

TABLE II

APPROXIMATE ENERGY ACCOUNT FOR 3-KILOWATT GENERAL ELECTRIC WATER-COOLED STUDIO FLOODLIGHT

Distribution of Input Power[2]		Per Cent of Total		Approximate Watts
Ultraviolet			5.7	200
Divided as follows	Less than 2,800 Å	0.00		
	2,800– 3,165	0.42		
	3,165– 3,800	5.30		
Visible			23.60	823
Divided as follows	3,800– 5,000	12.10		
	5,000– 6,000	8.50		
	6,000– 7,600	3.00		
Infrared			6.1	214
Divided as follows	7,600–14,000	6.10		
	14,000–26,000	0.00		
Carried off by cooling water			55.6	1,953
Transformer and control losses			9.0	315
Total energy input			100.00	3,510

From Table II it can be seen that of the total wattage input to each luminaire only slightly more than one third is actually radiated into the studio, either as ultraviolet, light, or heat. Luckiesh and Taylor[3] rate the energy per foot-candle from H-6 lamps at 4 micro-watts per square centimeter compared to $7\frac{1}{2}$

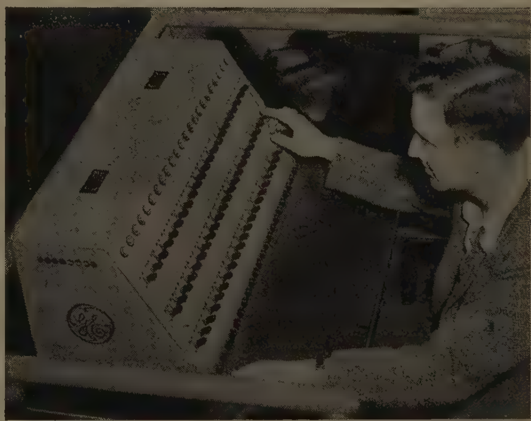

FIG. 9—Lighting console.

[2] B. T. Barnes, W. E. Forsythe, and W. J. Karash, "Spectral distribution of radiation from lamps of various types," *Gen. Elec. Rev.*, vol. 42, pp. 540–543; December, 1939.

[3] Matthew Luckiesh and A. Hadley Taylor, "Cool light," *Gen. Elec. Rev.*, vol. 43, pp. 410–411; October, 1940.

micro-watts per square centimeter for noon sunlight through $\frac{1}{8}$-inch window glass, making this lamp *much cooler per foot-candle than noon sunlight.*

Recent Experience with WRGB Installation

Lamps

On March 30, time meters were placed on two floodlights in different parts of the installation. On the basis of studies of the resulting data, the average operating time for the lights has been 15 hours per week for the past eleven weeks to June 17. The average lamp life during that period has been 72 hours, exclusive of floor-lamp units which were not included. The rated life is 75 hours of operation in periods of 25 minutes per start. Longer periods of operation per start tend to increase the lamp life. Performance at the World's Fair, where the lamps operated continuously during each day for approximately 10 hours, ran approximately 300 hours, average. Those lamps were produced

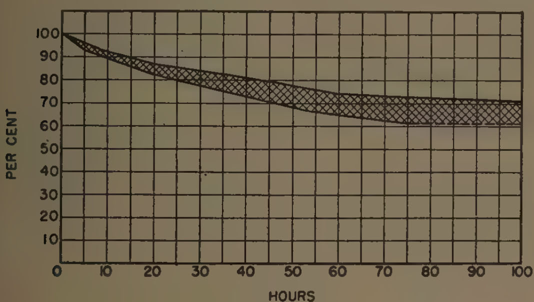

Fig. 10—Lumen maintenance of lamps.

in the laboratory. Factory production is just getting into full swing and as production increases and practices improve the life should increase toward the 300-hour average of the World's Fair depending somewhat on the operating cycle just how far it goes.

The average spread of lumen maintenance during the life for three groups of lamps is shown in Fig. 10. Initially the drop is quite rapid as with all electrical-discharge lamps. The stability through life is not quite so good as with some lower temperature lamps, but a very large output is generated from a small space making the lamp extremely valuable where high-intensity illumination is required.

Monitor-Tube Photos

Three pictures of the line monitor on one channel are shown. (Fig. 11.) The exposure was 2 seconds at $f/8.0$ on Eastman Panatomic X film. The detail is good, exceeding 350 lines.

Back lighting of the iconoscope is used and no difficulty is experienced with ripple except from the floor lamps in which one lamp is closer to the reflector opening and therefore more effective than the other two at very close ranges. A more nearly planar positioning of the lamps should improve this item.

(a)

(b)

(c)

Fig. 11 (a, b, and c)—Line monitor photos.
Peak tube brightness—4
Exposure—2 seconds at $f/8.0$
Film—Panatomic X
Image—normal on 12-inch tubes

Light ripple introduced by lamp burnout during a performance depends mainly on the number of floods covering the scene at the time. It is probably safe to say that with four 3-phase lights per set one burnout would not be detected.

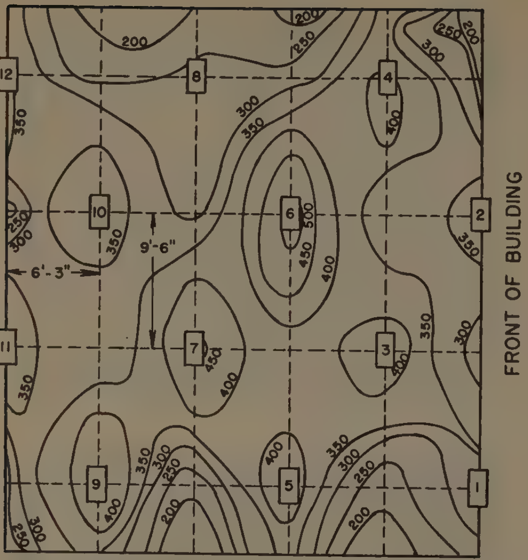

Fig. 12—Isolux chart of studio illumination. ☐ Type L-71 Novalux water-cooled floodlight with 3 A-H6 Mazda lamps. Nominal input 3500 watts.

Mounting height to light center 14 feet, 8 inches
Total lighting load 40 kilowatts
Average illumination at floor level 315 foot-candles
Illuminated area approximately 1500 square feet
Lumens per watt per square foot of illuminated area 11.8
Average age of lamps at time of test 20.8 hours

Light-Output Performances

The etched Alzak-finished aluminum reflectors shown in Fig. 3 were later changed to polished chrome-plated copper which was the wartime substitute for polished Alzak aluminum. The polished reflector was found desirable to aid in piling more light on the set from distant floodlights and, while the polished chromium has an 18 per cent lower reflection factor than polished Alzak aluminum, still the directional beam is considered more useful than the softer beam from the original reflector. The maximum candle power at the rated average lamp life is approximately 70,000.

As to actual light performance from the installation, Fig. 12 shows an isolux chart prepared from data taken on June 17 when the average life of the lamps then in service was approximately 21 hours. The average foot-candles with all the floods pointed downward and oriented with the long axis of the reflector across the room was 315 foot-candles. It is possible to build up the intensity over a 10- ×15- ×10- foot high scene to 650 or more foot-candles of general lighting, with the upper portions of the scene reaching 1000 foot-candles. By supplementing this lighting with floor lamps, good pictures are produced with little or no discomfort to the performers. This "no-discomfort" feature is the crowning achievement of this high-intensity lighting system.

A New Type of Practical Distortion Meter*

J. E. HAYES†, ASSOCIATE, I.R.E.

Summary.—This paper gives a description of a distortion meter embodying circuits which differ somewhat from the types previously employed for this type of instrument. It consists essentially of a bridged-T audio-frequency bridge circuit, in which the inductance element is replaced by a reactance-tube circuit. Because of the flexibility obtainable in vacuum-tube circuits, it is a relatively simple matter to vary the effective inductance continuously over a fairly wide range, and thus allow the distortion meter to be used at any frequency in the audio range.

Certain precautions must be taken in a circuit of this type in order to avoid difficulties due to nonlinear action of the reactance-tube circuit. Application of negative feedback to the reactance-tube circuit effectively reduces the nonlinearity, increases stability, and at the same time keeps tube noise and hum at a minimum level. An analysis of the reactance part of this circuit, together with formulas for calculating the effective Q and the optimum operating conditions are included.

Although the study of the properties of the reactance-tube circuit with negative feedback was limited to features applicable to the problem at hand, some of the information obtained may be of use in other fields.

THE development of the distortion-measuring instrument described here was prompted by two conditions. First, commercially available instruments were usually either rather critical in adjustment or else could be used only on certain predetermined frequencies and second, the instruments which were on the market could not be obtained without a high priority rating.

Desirable characteristics for a distortion meter include ease of operation, a minimum number of controls, good stability, continuous frequency coverage, and operation independent of any direct connection with the source of the test frequency. The last feature simplifies distortion measurements on lines and over-all checks from transmitter input to receiver output.

Fundamental Circuit

A simple method of distortion measurement is based on the bridge circuit[1] of Fig. 1. At a frequency such that,

$$\omega = \frac{1}{\sqrt{2L_pC}}\cdot$$

the bridge may be balanced by making

$$R_B = \frac{2}{\omega QC}$$

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† Transmission and Development Department, Canadian Broadcasting Corporation, Montreal, Que., Canada.

[1] W. N. Tuttle, "Bridged-T and parallel-T null circuits for measurements at radio frequencies," Proc. I.R.E. vol. 28, pp. 23–29; January, 1940.

so that $e_2=0$ at terminals 3 and 4 when a voltage e_1 of the above frequency is applied to terminals 1 and 2. At all other frequencies of e_1 the voltage e_2 will have a value dependent on the characteristics of the bridge elements.

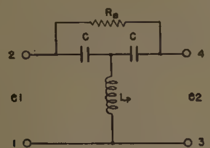


FIG. 1—Bridged-T bridge circuit.
Circuit relations

$$\omega = \frac{1}{\sqrt{2L_pC}}$$

$$R_B = \frac{2}{\omega QC}$$

for $e_2 = 0$

Fig. 2 shows the absolute value of e_2 as the frequency of e_1 is varied and its amplitude held constant. The curves show the effect of variation in Q of the inductance arm of the bridge and indicate that if a Q of 7 or better is maintained in the inductance, the effect of the bridge on harmonics of the null frequency will be negligible. This provides an effective method of eliminating the fundamental so that any harmonics present may be measured across terminals 3 and 4.

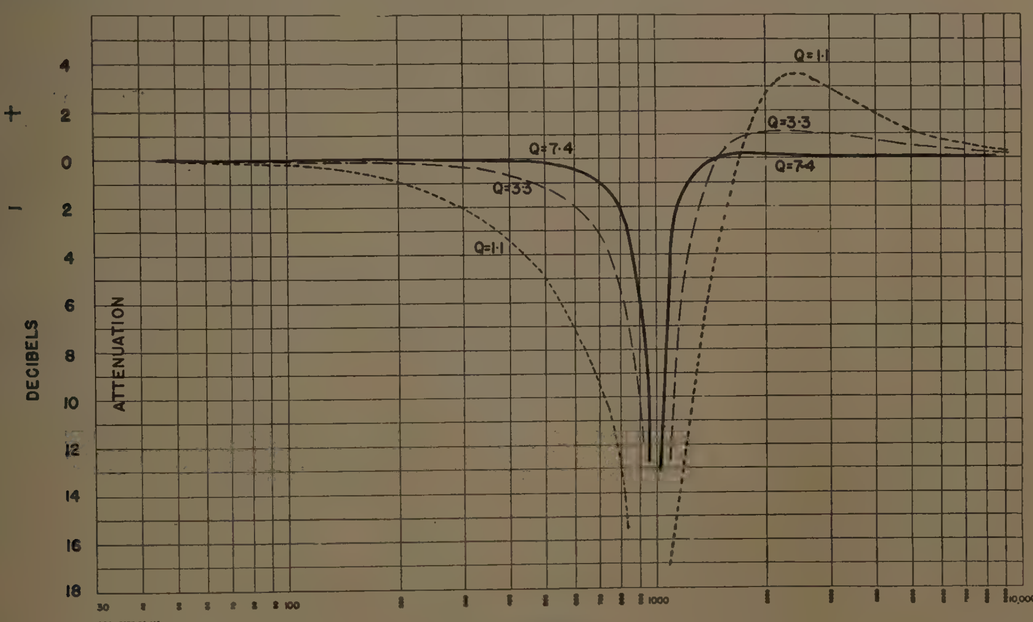


FIG. 2—Attentuation of bridged-T bridge circuit using air-core inductance.

To be useful at any frequency, means must be provided for adjusting the L and C arms of the bridge. Practical considerations, such as the impedance of the bridge arms and physical size of the condensers require that the inductance have a range of from 0.04 to 40 henries. Besides covering this range, the inductance should have a sufficiently high Q at the frequency at which it is used to provide the desired frequency characteristics in the bridge circuit. A vacuum-tube reactance circuit was developed which had the characteristics necessary for the purpose.

Electronic Inductance

Fig. 3 shows a simplified reactance-tube circuit in which the voltage applied to the grid of the vacuum

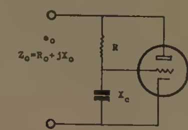


FIG. 3—Simplified reactance-tube circuit. Z_0 is the effective impedance at the input terminals.

tube is retarded almost 90 degrees with respect to e_0 by making R large with respect to X_c. The plate current, therefore, also lags e_0 by almost 90 degrees producing an effective inductance at the input terminals.

Fig. 4 is a vector diagram of the voltage and current values of such a circuit. The grid-voltage vector e_g and plate-current vector i_p are not to scale but are exaggerated for the sake of clarity.

Fig. 3 represents either a single tube or an amplifier of more than one tube, having an effective output impedance R_p, the output voltage e_p 180 degrees out of phase with the input voltage e_g, and a voltage gain

$$G = \frac{e_p}{e_g}.$$

Then

$$e_g = e_0\left[\frac{-{}_jX_c}{R - {}_jX_c}\right]$$

and

$$e_p = -G\cdot e_g = G\cdot e_0\left[\frac{{}_jX_c}{R - {}_jX_c}\right]$$

$$i_p = \frac{e_0 - e_p}{R_p} = \frac{e_0}{R_p}\left[1 - \frac{{}_jX_cG}{R - {}_jX_c}\right].$$

If the phase-shifting network impedance $R - {}_jX_c$ is made much greater than the desired terminal im-

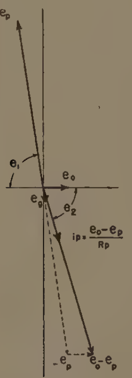


Fig 4—Vector diagram of reactance-tube circuit.

$$\theta_1 = \tan^{-1}\frac{R}{X_c}$$

$$\theta_2 = \text{phase angle of } Z_0$$

$$G = 44$$

$$\frac{R}{X_c} = 6\cdot 7$$

$$Q = \tan\theta_2$$

pedance Z_0, the admittance of the phase-shifting network may be neglected in the calculations of Z_0,

$$Z_0 = \frac{e_0}{i_p} = \frac{R_p}{1 - \dfrac{{}_jX_cG}{R - {}_jX_c}}\cdot$$

Rearranging gives

$$Z_0 = R_p\left[\frac{R^2 + X_c^2(1+G)}{R^2 + X_c^2(1+G)^2} + J\,\frac{X_cRG}{R^2 + X_c^2(1+G)^2}\right] \qquad (1)$$

from which the Q of the impedance is

$$Q = \frac{X_0}{R_0} = \frac{X_cRG}{R^2 + X_c^2(1+G)}\cdot \qquad (2)$$

By differentiation we find the condition for maximum Q,

$$\frac{R}{X_c} = \sqrt{1+G}. \qquad (3)$$

Substituting (3) in (2) gives

$$\text{maximum } Q = \frac{G}{2\sqrt{1+G}}\cdot \qquad (4)$$

In a more convenient form,

$$X_0 = +{}_jR_p\frac{\dfrac{R}{X_c}G}{\left(\dfrac{R}{X_c}\right)^2 + (1+G)^2} \qquad (5)$$

$$Q = \frac{\dfrac{R}{X_c}G}{\left(\dfrac{R}{X_c}\right)^2 + 1 + G}\cdot \qquad (6)$$

Equation (5) may be rearranged in the form,

$$L_0 = \frac{R_pRCG}{(R\omega C)^2 + (1+G)^2} \text{ in which } (R\omega C)^2 \text{ is negligible.}$$

$$L_0 = \frac{R_pRCG}{(1+G)^2}\cdot \qquad (7)$$

In designing an electronic reactance, (4) is used to determine the gain required in the amplifier section to provide the desired Q. The constants of the other parts of the circuit may then be calculated from (3) and (5). Equation (6) is then used to find the Q at any frequency other than that for which the maximum Q is obtained.

Practical Circuit of Electronic Inductance

In the reactance circuit used in the distortion bridge (Fig. 5), two tubes are required to obtain the desired results. A pentode tube provides the necessary gain while a triode used as a cathode follower maintains the proper phase relationship and gives the low output impedance necessary for low values of reactance. Smooth control of the reactance is obtained by a

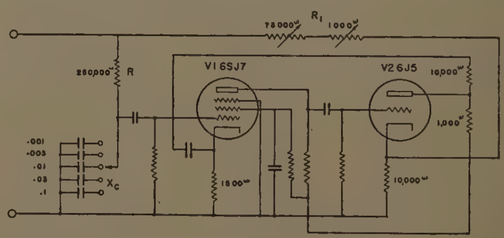


Fig. 5—Electronic inductance used in distortion meter.

variable resistor R_1 (consisting of a "coarse" and a "fine" adjustment) which changes the effective output impedance R_p of V_2. As can be seen from (5) and (6) the reactance is directly proportional to R_p but the Q is not affected by it. Furthermore, any instability due to variation in output impedance r_p or V_2 is reduced in the ratio

$$\frac{r_p}{R_1 + r_p}.$$

The effective inductance of the circuit is changed in 3-to-1 steps by one section of a gang switch selecting any one of five phase-shifting condensers. Two other sections of the gang switch change the condensers in the bridge arms in similar steps, so that by providing a 10-to-1 range of R_p, and, therefore, of the effective inductance of the circuit, it is possible to balance the bridge at any frequency within its range of 30 to 10,000 cycles. Since any one phase-shifting condenser is used only over a 3-to-1 frequency range, if the circuit constants are adjusted to provide the optimum value of R/X_c at the middle of each range the Q will still be reasonably good at either end of the range.

The addition of negative feedback stabilizes the gain of the tubes and at the same time reduces noise and distortion. Without the use of negative feedback, line-voltage fluctuations cause sufficient changes of gain and, therefore, of reactance, that the null settings of the bridge circuit are unstable. Since distortion or noise introduced by the tubes in the reactance circuit

of 6.7. While this Q is somewhat lower than might seem desirable, it is difficult to obtain a higher value without sacrificing some stability or increasing the complexity of the circuit. It was felt that for practical purposes the accuracy obtainable with this circuit was sufficient.

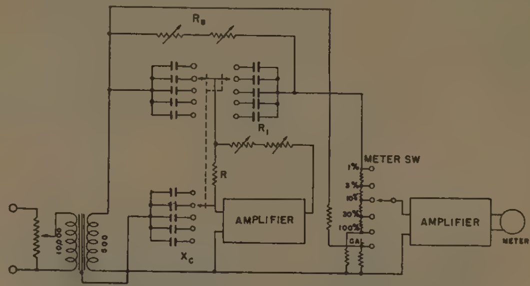


FIG. 6—Simplified circuit of distortion meter.

The attenuation characteristics are shown in Fig. (7). The curves shown for "LOW," "MID," and "HIGH FREQUENCY" were actually taken for 300-, 600- and 1000-cycle balance points on the 300- to 1000-cycle

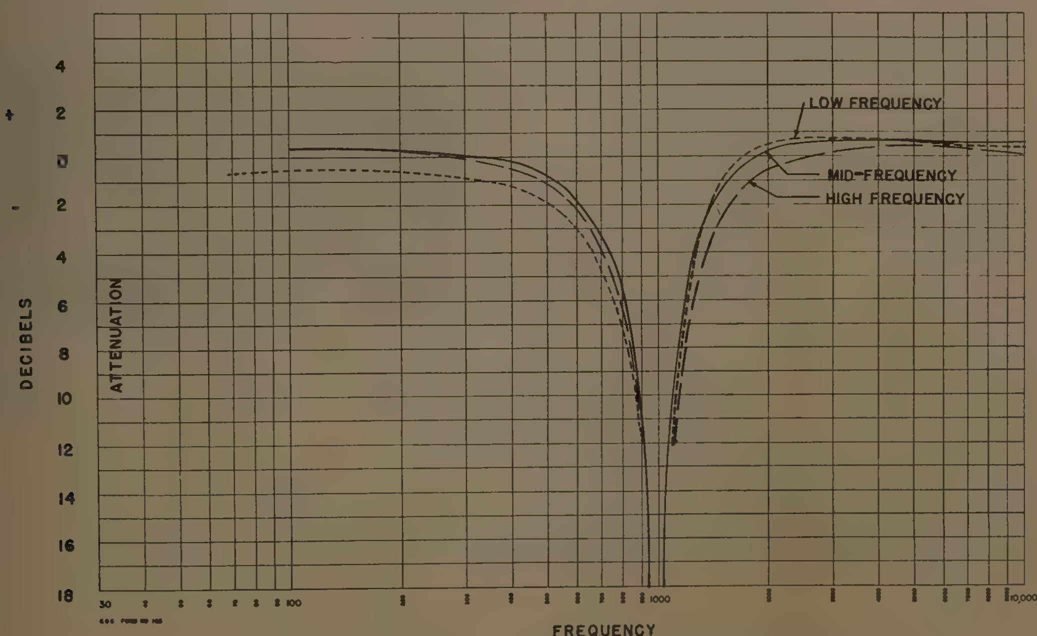


FIG. 7—Over-all characteristics of distortion meter using electronic inductance.

can cause a false reading on the indicating meter, it is essential that both be kept to a very low level.

APPLICATION TO DISTORTION METER

Fig. (6) shows the circuit of the electronic inductance as applied in the distortion meter. The amplifier section has a gain of 44 and an output impedance of 5350 ohms. The maximum Q obtained is 3.3 for a ratio R/X

range of the bridge but are shown plotted on the 1000-cycle point in order to facilitate comparisons. The variation in shape of the curves is caused by the variation in the ratio of R/X_c as the bridge is balanced for different frequencies. These curves are somewhat flatter than those of Fig. (2), probably because, while the Q of an air-core inductance increases with frequency in the audio range, the Q of an

electronic inductance decreases slowly after the frequency-producing optimum R/X_c ratio is exceeded.

Combined Balancing Controls

From (7) it may be seen that if R_p and R are varied simultaneously in proportion to the rotation (θ degrees) of a dial, $L_0 = K\theta^2$, where K includes all the individual constants. Therefore, the null frequency of the bridge will be inversely proportional to the dial rotation. Since the reactance X_c of the condenser in the phase-shifting circuit also varies inversely with frequency, conditions are obtained which makes the ratio R/X_c constant. This results in L_0 having a constant Q no matter what null frequency is used in the bridge circuit. Greater accuracy is obtainable in the distortion meter since the variations shown in Fig. (7) are considerably reduced.

Fig. 8—Experimental model of the distortion meter.

The balancing resistor in the bridge circuit has a value $R_B = 2/\omega QC$ and consequently varies inversely with frequency if Q and C are held constant. Therefore, R_B may be operated simultaneously with R_1 and R by the same control knob. This combined control of both resistive and reactive balance of the bridge circuit makes operation of the instrument very simple. The accuracy with which the bridge may be balanced with the single control knob is dependent on the proper ratio being maintained at all times for the three variable resistors. Two "fine controls" which consist of low-value variable resistors, one as part of R_B and the other as part of R_1, can compensate for a reasonable amount of mistracking in the ganged controls, making an exact balance easily obtainable. A 3-to-1 frequency range is obtained on the ganged control by placing fixed resistors of suitable value in series with R, R_1, and R_B.

In an experimental model of the distortion meter, satisfactory operation was obtained by ganging ordinary receiver-type volume controls having a linear taper. Not all controls tried, however, were sufficiently close to their rated resistance or taper to track properly. One advantage of the circuit using separate controls for R_1 and R_B is that none of the parts, with the exception of the meter multiplier resistors, need be held to close tolerance. Fig. 8 is a photograph of the experimental model of the instrument.

The controls appearing on the front panel have the following functions:

1. A "calibrate" knob to set the incoming test tone to the proper level.
2. A "frequency" control (R_1) and its associated range switch. The accuracy of the frequency calibration is dependent on the tolerances of the fixed condensers of the bridge arms and the elements determining the value of L_0.
3. A "balance" control (R_B) which may be omitted from the front panel and ganged with the "frequency" control if desired.
4. "Fine" adjustments for the "frequency" and "balance" controls.
5. A "meter" switch to provide the desired meter sensitivity.

The amplifier preceding the meter consists of two 6SJ7 pentodes and a 6J5 triode. Negative feedback is used across the two pentodes to stabilize the gain. The 6J5 is run at very low plate voltage so that its output cannot exceed a safe value for the meter. The meter is a standard copper-oxide-type vu meter with the addition of a special meter scale. It is coupled through a suitable series resistor and condenser to the plate of the 6J5 tube. Full-scale deflection of the meter is obtained with about 0.5 millivolt at the input of the amplifier.

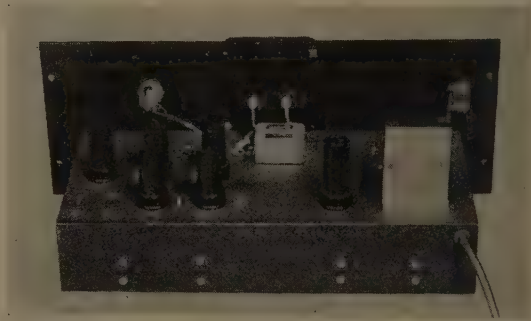


Fig. 9—Rear view of the instrument. Two tubes are in the electronic reactance circuit, three in the amplifier preceding the meter, and one in the power supply.

Conclusion

The above application of an electronic reactance provides a good example of its flexibility. Certain limitations are, however, inherent in a reactance circuit of this type.

1. It can be used only in relatively low-voltage circuits.
2. The Q of the circuit drops off on either side of some optimum frequency.
3. Care must be taken in the design of the amplifier portion that phase shifts introduced by it do not cause the circuit to break into oscillation.

Acknowledgment

The writer wishes to express his appreciation to Mr. J. A. Ouimet, Assistant Chief Engineer of the Canadian Broadcasting Corporation, for his interest and helpful discussions during the progress of the work on this subject.

Appendix

1. Accuracy of Formulas

The accuracy of the formula giving the value of the effective inductance of the circuit was checked by independent measurements. Excellent agreement between the calculated and the measured value was obtained.

(a) The distortion meter was first adjusted for operation on 1000 cycles and then the values of R_p, R, C, and G were carefully measured.

Equation (5) was used to obtain the value of X_0.

(b) A General Radio 650A impedance bridge was then used to measure the electronic-inductance part of the circuit and a correction, in this case about 1 per cent, applied to allow for the admittance of the phase-shifting network.

(c) A third result was obtained from the formula for the null condition of the bridged-T bridge circuit, $L_p=1/2C\omega^2$. Since, in this case L_p is the effective parallel inductance it was converted to the effective series inductance and the proper correction allowed for the admittance of the phase-shifting network.

The three methods gave respectively, 0.362, 0.361, and 0.363 henries. The variation is well within the accuracy of the General Radio bridge.

In a similar manner the Q of the electronic inductance was checked. The calculated values were 3.12 and 3.13 and the value measured on the General Radio bridge 3.0. The discrepancy between calculated and measured Q is again within the accuracy of the method of measurement.

2. Effect of Line-Voltage Variations

The stability of the electronic-reactance circuit is sufficiently good that no voltage regulation is necessary. The controls on the distortion meter were adjusted for a null balance of its bridge circuit at 1000 cycles. The line voltage was then varied above and below its normal value of 110 volts and the change in the null frequency of the bridge circuit determined.

Line Voltage Volts	*Frequency* Cycles
90	995.0
100	997.8
110	1000.0
120	1002.7
130	1004.5

The average change in bridge null frequency is, therefore, about 0.025 per cent per volt change in line voltage. Since the null frequency of the bridge circuit is determined by

$$\omega=\frac{1}{2\sqrt{L_pC}}$$

the variation in the inductance would, therefore, be close to 0.05 per cent per volt change in line voltage.

3. Circuit Stability

Since the gain of two tubes in the electronic-inductance circuit is stabilized by the application of 14 decibels of negative feedback, the effect of variation in tube characteristics is relatively small.

The circuit of Fig. 5 shows no tendency to oscillation and is perfectly stable in that respect. However, some circuits using conventional triode amplifiers with an interstage transformer were found to be quite impracticable as they oscillated continuously.

4. Instrument Accuracy

As indicated by the curves of Fig. 7, a slight variation in the attenuation of harmonics existed in the experimental model. The variation is about plus or minus $\frac{1}{2}$ decibel from the average or about 5 per cent of the meter indication. Thus, if the meter indicated 1 per cent distortion the actual value would be between the limits of 0.95 and 1.05 per cent. This accuracy is improved by ganging the controls R, R_1, and R_3, as discussed previously. The variations are then reduced to approximately plus or minus 2 per cent.

5. Sensitivity

At maximum sensitivity the instrument will give a full-scale reading on its meter for 1 per cent distortion present in the wave being tested. Residual hum and circuit noise give an initial meter reading of 0.05 per cent or less, which is quite negligible for practical purposes.

Institute News and Radio Notes

Wartime Engineering Accomplishments

Reviewing the accomplishments of radio engineers and their industry in 1942, James T. Buckley, President of the Philco Corporation, speaks in terms encouraging to our engineering members. In part he states:

"To meet the needs of the war emergency, the radio manufacturing industry has achieved new engineering and production miracles in 1942, and further technical progress and manufacturing accomplishments are confidently expected in 1943.

"Instantaneous communication between land, sea, and air forces was never more important than it is in this global war we are fighting. Every military action has a direct bearing on the whole worldwide struggle, and there must be dependable, uninterrupted communications facilities available at all times. Modern radio equipment is meeting this test under the most difficult combat conditions in remote corners of the earth. . . .

"In many ways besides the furnishing of instantaneous communications service, radio is helping to win the war. It is common knowledge that only the use of electronic equipment made it possible for England to win the Battle of Britain. Many of the "secret weapons" now in use by the United Nations are the result of new practical applications given to radio and television principles. Very recently Prime Minister Churchill said that the development and production of aircraft and the extension of radio research would be, in his opinion, two of the most important factors in winning the war.

"The knowledge and skill that are contributing to the winning of the war will later be turned again to the arts of peace. When the time comes, the work being done now should result in major improvements in radio transmitting and receiving techniques. Of even more importance, the art of television should be so far advanced that it will be ready to become the basis of an entirely new and great industry."

Winter Conference—1943

The one-day Winter Conference, held on January 28, 1943, in New York City, took place concurrently with the National Technical Meeting of the American Institute of Electrical Engineers in session during the week at the Engineering Societies Building there.

Despite a snowstorm of blizzard proportions, approximately 450 members and guests attended the morning technical session, 350 the afternoon session, and 600 the evening meeting and broadcast.

Morning Technical Session

The program of the morning session, extending from 10:00 A.M. to 12:30 P.M., consisted of the following technical papers:

"Radio-Frequency-Operated High-Voltage Supplies for Cathode-Ray Tubes," by O. H. Schade, RCA Manufacturing Company, Inc., Radiotron Division, Harrison, N. J.

"Transmission-Line Charts," by R. S. Julian, Bell Telephone Laboratories, Inc., Whippany, N. J.

"Polydirectional Microphones," by H. F. Olson, RCA Manufacturing Company, Inc., Victor Division, Camden, N. J.

"Phosphors and the Periodic System of the Elements," by H. W. Leverenz, R.C.A. Communications Laboratories, Princeton, N. J.

"Direct-Reading Wattmeters for Use at Radio Frequencies," by G. H. Brown, J. Epstein, and D. W. Peterson, RCA Laboratories, Princeton, N. J.

Afternoon Session and Annual Meeting

The afternoon program, continuing from 2:30 P.M. to 5:00 P.M., is summarized below:

"Address of Retiring President," by A. F. Van Dyck, President for 1942.

Formal Induction of Dr. L. P. Wheeler, President for 1943, and Transfer-of-Gavel Ceremony.

Introduction of F. S. Barton of England, Institute Vice President for 1943.

Presentation of the Medal of Honor of the Institute to Dr. William Wilson.

Presentation of Fellowship Awards and Diplomas to Andrew Alford; I. S. Coggeshall, Captain J. B. Dow, Dr. P. C. Goldmark, D. E. Harnett, D. D. Israel, A. G. Jensen, Lt. Col. G. F. Metcalf, Dr. Irving Wolff (*in absentia*), and at Boston Section Conference to Dr. L. A. Du Bridge.

"Electric Communications—The Past and Present Illuminate the Future: A Suggestive Interpretation," by Lloyd Espenschied, Consultant, Bell Telephone Laboratories, Inc., New York, N. Y.

"Production of Radio Facilities for the Armed Services," by Rear Admiral S. C. Hooper, United States Navy, General Consultant for Radio, Radar, and Underwater Sound Equipment (read by Commander J. L. Allen, Eastern Sea Frontier Communications Officer, New York, N. Y.).

"The Army-Navy Electronics Production Agency," by F. R. Lack, Director, Army-Navy Electronics Production Agency.

"The Function of the War Production Board in Radio," by Ray Ellis, Director, Radio and Radar Division, War Production Board.

"Radio Standards Go to War," by H. P. Westman, War Committee on Radio, American Standards Association, New York, N. Y.

"The Engineer's Position in the Manpower Program," by Kirk Miles, National Roster of Scientific and Specialized Personnel, War Manpower Commission.

Question-and-Answer Period.

Joint Evening Meeting with A.I.E.E.

The following joint-meeting program began at 8:30 P.M. and with the special broadcast concluded the conference at 10:45 P.M.:

Haraden Pratt, Past Institute President and Chairman of A.I.E.E. National Committee on Communications, Presided.

Address of the Evening: "Beyond the Ultra Shorts," by Dr. G. C. Southworth, Bell Telephone Laboratories, Inc., New York, N. Y.

Personal Greetings and Reminiscences, by Sir Noel Ashbridge, Fellow of the Institute, Chief Engineer, British Broadcasting Corporation, London, England (transmitted by beam telephone and heard at meeting from transcription).

Nation-wide Radio Broadcast (via CBS): Brief Addresses by Dr. L. P. Wheeler, Institute President for 1943 and A. F. Van Dyck, Retiring President, from New York, N. Y.

"Radio Engineering in Wartime," by the Honorable James Lawrence Fly, Chairman, Board of War Communications and Federal Communications Commission, from Washington, D. C.

Preprint copies of the papers were *not* made. However, it is the intention to publish as many of these conference papers as possible in forthcoming issues of the PROCEEDINGS.

The committee responsible for the Institute's conference arrangements consisted of I. S. Coggeshall, chairman; Austin Bailey, E. K. Cohan, D. D. Israel, H. M. Lewis, and H. A. Wheeler.

Ten Sections Hold Winter Conferences

Ten Sections throughout the United States and Canada held separate technical conferences simultaneously with the one at New York City on January 28, 1943.

The participating Sections were Boston, Cincinnati, Detroit, Kansas City, Montreal, Portland, St. Louis, San Francisco, Toronto, and Washington.

Members of the Connecticut Valley, New York, and Philadelphia Sections attended the conference in New York City, which was sponsored by the Institute.

As the conference reports from Sections are received, they will be published in the PROCEEDINGS.

Board of Directors

The Annual Meeting of the Board of Directors took place on January 6, 1943, and was attended by L. P. Wheeler, president; F. S. Barton, vice president; W. L. Barrow, W. L. Everitt, H. T. Friis, Alfred N. Goldsmith, editor; O. B. Hanson, F. B. Llewellyn, F. E. Terman, B. J. Thompson, H. A. Wheeler, and W. B. Cowilich, assistant secretary.

To serve during 1943, R. A. Heising was appointed treasurer, Haraden Pratt was named secretary, and Alfred N. Goldsmith was reappointed editor.

These five directors were appointed for 1943: S. L. Bailey, E. F. Carter, I. S. Coggeshall, G. E. Gustafson, and W. C. White.

H. M. Turner was designated to fill the vacancy of elected director for 1943.

Appointment was made of the personnel to serve on the 1943 Awards, Constitution and Laws, Executive, Nominations, and Tellers Committees.

Approval was given to the change in rate of compensation paid to Mr. W. C. Copp for soliciting advertising in the PROCEEDINGS.

It was voted to transfer A. B. Bailey, H. V. Griffiths, and J. A. Stobbe to the Member grade. J. C. Bayles, S. T. Fisher, and D. L. Hathaway were elected to the grade of Member.

Also, 168 Associates, 296 Students, and 8 Juniors were elected to the named grades of membership.

The employment of Klauser and Todt, C.P.A., to make the financial audit of Institute's 1942 records, was confirmed.

A budget for 1943 was adopted.

Editor Goldsmith reported on the prospects for obtaining additional papers for the PROCEEDINGS.

The personnel of the 1943 Admissions, Public Relations, Sections, Membership, Papers, Papers Procurement, and Registration of Engineers Committees, as well as Board of Editors, was named.

The following resolution on deferment of engineering students was passed:

"*WHEREAS:* The greater and greater requirements for engineers needed both by the armed services and by the industries supplying them have brought about an acute shortage of both experienced and student engineers, and

"*WHEREAS:* A particularly acute shortage of radio engineers has developed due to the complex and manifold radio communication and other allied radio requirements of present-day welfare, and

"*WHEREAS:* It appears that the demand for trained engineers is increasing, and if a continuous flow thereof is not assured for the future, serious dislocation of the entire war effort may result, and

"*WHEREAS:* A factual survey does not appear to be available upon which a rational plan for the training and distribution of professional manpower may be formulated, and

"*WHEREAS:* Occupational Bulletin No. 10, amended December 14, 1942, recommends deferment of a draft registrant who is in training only if he has completed his first academic year of study, and

"*WHEREAS:* If Freshman students in engineering schools are not deferred, there will be, in addition to a future curtailment in the flow of young engineers, the danger that the teaching staffs may become dispersed and the machinery of technical education become seriously affected at a time when it may be most needed.

"*THEREFORE, BE IT RESOLVED:* That the Board of Directors of The Institute of Radio Engineers, at its Annual Meeting held in New York City, January 6, 1943, urges that an adequate supply of engineers be maintained by preserving the status of engineering students and particularly students specializing in radio and allied branches of engineering.

"That this be accomplished by granting a deferred classification under the Selective-Service procedures to individual students maintaining a satisfactory scholarship record in schools of recognized standing.

"That such deferment be temporary until a comprehensive study of shortages and surpluses (if any) is available, together with a satisfactory program covering the training, supply, and distribution of technical personnel for the future."

President Wheeler was appointed chairman of the committee on draft deferment of radio personnel.

A. F. Van Dyck was added to the committee on War Service Awards.

Executive Committee

A special meeting of the Executive Committee was held on January 6, 1943, and those in attendance were Alfred N. Goldsmith, editor and acting chairman; F. B. Llewellyn, B. J. Thompson, L. P. Wheeler (president-elect; guest); and W. B. Cowilich, assistant secretary.

Leslie J. Woods

With a long record of pioneering in the radio industry behind him, Leslie J. Woods has been named vice president and general manager of the National Union Radio Corporation, manufacturers of radio tubes and electronic devices, it was announced today by S. W. Muldowny, president.

Born in England, Mr. Woods studied at the London Telegraph Training College, and later had commercial experience in Denmark and Russia. From 1915 to 1918 he served in the British Army in France, becoming a Second Lieutenant in the Royal Engineers. Later he joined the North Persian Expeditionary Force as Officer in Charge of Wireless Communications. From 1919 to 1923, Mr. Woods served first in military and then in civilian capacities in the Middle East, helping to develop a world-wide communications system with the construction of wireless stations in Hamadan, Teheran, and Baghdad.

In 1923, he decided to make his home in the United States and began a long connection with Philco. Following several years service as district representative in California, he joined the Engineering Department of the Company in Philadelphia as First Television Engineer in 1928. From 1930 to 1938 he contributed in substantial measure to the growth of the Company as engineer in charge of export radio receivers and vacuum-tube development. For the following three years, Mr. Woods was in Detroit with the Auto Radio Division of Philco, becoming General Manager of the Division in 1941. Upon the outbreak of war, because of his engineering knowledge and experience, Mr. Woods was transferred to Washington to assist in carrying through the large commitments for communications equipment that the Government has asked Philco to undertake.

Mr. Woods became a Member of the Institute in 1935.

Books

The Electrical Fundamentals of Communications, by Arthur L. Albert.

Published, 1942, by the McGraw-Hill Book Company, 330 W. 42 St., New York, N. Y. 546 pages+8-page index+vi pages. 359 figures. 6×9 inches. Price $3.50.

This book seems well adapted for use by the individual who has derived a working knowledge of radio technique and kindred subjects the easy way, working around with the apparatus. Such experience often brings about complete familiarity with electrical processes with but little knowledge of the principles involved. The book deals almost entirely with the analysis of electrical terms, laws, and measurements as applied to communications, particularly radio. The presentation is such that the book can be used for home study as well as for a classroom text. Any technician who is finding difficulty either in understanding others or expressing his own ideas in the language of the engineer, will find help here.

While the book omits all references to actual electronic applications and complete circuits, all of the common electrical equipment items are discussed as circuit elements and described as to their functions in the usual applications.

After a simple explanation of each subject, the general plan is to describe measuring instruments and technique in that field and the fundamental mathematical principles involved, requiring only a working knowledge of algebra. Each chapter stands on its own feet, and can be studied in any order by anyone who has a general knowledge of the subject. At the end of each chapter three valuable features are included: the student (the term referring to the broad field of knowledge-seekers) having discovered that he is acquainted with the high lights as listed in the "Summary" then takes up a short list of "Review Questions." He then is given a well-chosen list of practical "Problems." These problems and examples parallel those distributed throughout the text. The text is particularly free from discrepancies and errors such as frequently appear in a first edition.

RALPH R. BATCHER
Hollis, L. I., N. Y.

Fundamentals of Radio, Edited by William L. Everitt.

From the work of Edward C. Jordan, Paul H. Nelson, William C. Osterbrock, Fred H. Pumphrey, Lynne C. Smeby. Published by Prentice-Hall, Inc., 70 Fifth Ave., New York, N. Y. 392 pages+8-page index+xiii pages. 273 figures. $6\frac{1}{4}\times9\frac{1}{4}$ inches. Price $5.00.

The present ever-increasing scarcity of trained radio personnel is requiring the employment of vast numbers of persons who are unacquainted with even the basic principles of radio communication. The difficulty of giving adequate training to these operators has usually resulted in each one becoming adept at one particular operation or test only. This book is well adapted to the providing of additional information about the whole subject and the basic plan of the art in which they have become active.

The book is all-inclusive for a beginner, starting with the study of the few arithmetical and algebraic principles needed to work out problems in the succeeding chapters. Following that, the book progressively builds up the reader's knowledge of electrical circuits (a-c and d-c), electronic principles, and the fundamentals of the modern radio communication art. The book is a timely and practical treatment of the art and while it will not in itself make a person a radio "engineer," a good serviceman, or a technical operator, it will provide the background for a subsequent study in any of the numerous fields of activity now open to beginners, whether they are training for industrial or military activity or for one operation of communication equipment in one of its various applications. It is quite possible that many radio salesmen and executives will also find the book an authentic and easily read source of information about the technical details of the problems with which they are concerned.

As listed above, the book has been developed by a group of educators and engineers who are well acquainted with the problems of training students in radio fundamentals. The various contributions (which are not identified as to their particular author) have been edited by Professor W. L. Everitt, whose activity in the field of radio broadcasting technique has long been recognized. The book is recommended for either a classroom text or for home study. Its 400 pages are crowded with practical examples and problems and contain 309 illustrations.

Ralph R. Batcher
Hollis, L. I., N. Y.

Principles of Electron Tubes, by Herbert J. Reich

Published by the McGraw-Hill Book Company, 330 West 42 St., New York, N. Y. 383 pages+13-page index+xv pages. 314 figures, $6\frac{1}{4}\times9\frac{1}{4}$ inches. Price, $3.50.

This is an abridgment of the author's "Theory and Application of Electron Tubes" published in 1939. Despite the fact that there has been a reduction of nearly 300 pages it still contains most of the essential material and is sufficiently comprehensive for a first course in electronics even for students specializing in the subject. As in the previous book the presentation is clear and orderly. The author, with his usual regard for precision of statement, has provided a substantial foundation in physical concepts, emission, space charge, grid control, glow- and arc-discharge tubes, and light-sensitive cells which in some respects is more effective than in the earlier volume. The space devoted to special applications such as amplifiers, oscillators, and electrical conduction in gases has been considerably reduced but will be found adequate for most purposes and has the added merit of being somewhat more readily available.

H. M. Turner
Yale University
New Haven, Conn.

A Graphic Table Combining Logarithms and Anti-Logarithms, by Adrian Lacroix and Charles L. Ragot

Published by the Macmillan Company, New York, N. Y. 56 pages. 7×10 inches. Price, $1.60.

This is the fifth reprint of a work first published in 1925. In it logarithms and anti-logarithms are presented by parallel scales of the numbers and their logarithms. These enable the five-place logarithm of a number, or the number corresponding to a five-place logarithm, to be obtained by the simple reading of a scale, without any necessary interpolation.

For this purpose there are provided forty pages of the juxtaposed scales. The usual table of five-place logarithms with proportional parts fills twenty pages only. However, in the present work, no interpolation whatever is necessary for five-place work, and by simple estimation of tenths of a division, six-place logarithms and six-place anti-logarithms are obtained. Thus these scales occupy much less space than the usual six-place logarithm table. In addition, a second table of only six pages is included in the book. From this may be taken, without interpolation, four-place logarithms and anti-logarithms, and simple estimation of tenths of a division gives all the accuracy of the usual five-place table.

The scales are beautifully and clearly executed and are sufficiently open to allow tenths of a division to be estimated with certainty. This method of obtaining logarithms and for making calculations using logarithms, should especially appeal to computers accustomed to use the slide rule.

A five-page introduction, with portions of the scales reproduced in the text for purposes of illustration, clearly and fully explains the use of the tables.

Frederick W. Grover
Union College
Schenectady, N. Y.

Microwave Transmission, by J. C. Slater

Published by the McGraw-Hill Book Company, Inc., 330 West 42 St., New York, N. Y. 304 pages+5-page index+x pages. 76 figures. $6\frac{1}{4}\times9\frac{1}{4}$ inches. Price, $3.50.

The scope of this book is clearly defined by its title. The first chapter occupies 78 pages and gives a lucid development of classical transmission-line theory. Material is included concerning lines with continuously varying parameters. The second chapter is a 5-page treatment of Maxwell's equations, plane waves, and reflection. As the author points out, this is not a treatise on electromagnetic theory. It does however, supply a clear physical interpretation of the meaning of Maxwell's equations. Especially good is the explanation of Maxwell's displacement current. In this chapter the author introduces the m-k-s units which should be gratifying to the worker in the field. The third chapter, comprising 26 pages, takes up the analysis of rectangular wave guides. The subject is introduced by a study of wave propagation between parallel planes. The material on rectangular wave guides is reasonably complete, including a derivation of the attenuation formulas. This is followed by a 43-page chapter dealing with the general transmission line from the viewpoint of Maxwell's equations. Parallel-wire lines, coaxial lines, and circular wave guides are treated. It is to be regretted that the material on the circular wave guide is so brief. This chapter also includes a good general discussion of reflection effects in lines due to changes in dielectrics, and changes in cross-section and iris diaphragms. The fifth chapter is a study of the radiation of electromagnetic energy from dipoles and antennas with a discussion of the recent calculations of Schelkunoff and of Stratton and Chu on the impedances of antennas. The remaining 69 pages of the book are devoted to directive devices for antennas and the coupling of coaxial lines to wave guides. There is a rather serions lack of material on electromagnetic horus. Parabolic reflectors are discussed in a qualitative way. The material on the coupling of coaxial lines to wave guides is of considerable interest.

As a whole, the reviewer is of the opinion that this book, while incomplete in some respects, is very well written and represents a good introduction to the study of microwaves. It should be a useful addition to the book shelf of either the beginner or the advanced worker in microwaves.

The teacher will need to supply his own problems as none is included in the text.

S. D. Robertson
Bell Telephone Laboratories, Inc.
New York, N. Y.

Fundamentals of Electric Waves, by Hugh Hildreth Skilling

Published by John Wiley and Sons, Inc., 440 Fourth Ave., New York, N. Y. 182 pages+4-page index+vii pages. 65 figures. $5\frac{3}{4}\times9$ inches. Price $2.75.

"Fundamentals of Electric Waves" is devoted exclusively to a thorough explanation of electromagnetic concepts and equations and of those vector concepts which have become part and parcel of electromagnetics. The book includes 40 pages of graphic discussion of vector fields, gradient, divergence, and curl. These chapters are followed by brief chapters on electrostatic field, electric-current flow, and magnetic fields. Thus, a proper foundation is laid for understanding Maxwell's equations. The final third of the book is devoted to uniform plane waves, power flow and Poynting vector, radiation, rudiments of antenna theory, and glimpses of guided-wave propagation. The exposition is very good.

The book is intended for undergraduate students and caters to those who wish to understand fundamentals; there is little specific information.

Gaussian units are used almost exclusively, but some final results are expressed also in practical units. Inasmuch as the primary purpose of the book is to help students and engineers to read modern literature on microwave transmission, in which m-k-s units are used amost exclusively, the author's choice of the units is perhaps unfortunate. However, the book is concerned primarily with ideas and units are not particularly important.

S. A. Schelkunoff
Bell Telephone Laboratories, Inc
New York, N. Y.

Aligning Philco Receivers, Volume II, 1941, by John F. Rider

Published by John F. Rider, Publisher, Inc., 404 Fourth Ave., New York, N. Y. 176 pages+xv pages. 167 figures. $5\frac{1}{4}\times7\frac{1}{2}$ inches. Price $1.60.

This volume supplements Volume I which appeared in 1937. It contains specific alignment instructions for all Philco receivers marketed between 1937 and the present time, since the manufacture of receivers was stopped in April, 1941. The tabular form of alignment instructions employed so successfully in the earlier volume has been retained. The Appendix treats problems of general interest to those concerned with receiver alignment. Such topics as signal strength, output meter, intermediate-frequency alignment, wave-trap alignment, oscillator adjustment, image check, etc., are covered.

This volume was compiled with the cooperation of the Philco Service and Engineering Divisions. It presents in compact form and with unusual clarity information regarding chassis layout, locations of the various trimmers and alignment procedures. Servicemen should find in this and in volume one, all the information necessary in their work on the alignment of "Philco Receivers."

W. O. Swinyard
Hazeltine Electronics Corporation
Chicago, Ill.

Principles of Radio, Fourth Edition, by Keith Henney

Published by John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. 1942. 536 pages+13-page index+xii pages. 310 illustrations. Price $3.50.

It is always difficult for a reviewer to know how to cope with a fourth edition of a book. If he should decide the book was no good, what could he do? Obviously many cash customers have disagreed with him, or there would be no fourth edition. Fortunately, Keith Henney saved this reviewer from such a conflict by writing a book which he can heartily recommend and endorse.

The book was written "for the student who had little background in radio upon which to build and yet who wanted to know the basis upon which radio communication existed." And it is consistently held at that level, suitable for the trade school, not for the college. In fact the author specifically states that the book is not designed for college use. The liberal sprinkling of well-graded problems leads one on from the simplest case to those of the maximum complexity consistent with the amount of mathematics available. It is a joy to this reviewer to find a book which admittedly does not fill all requirements in its field, but which does fulfill one requirement so well.

The book starts with a description of the electron and a statement of Ohm's law. It then discusses practical sources of current, circuit elements, resonance phenomena, the vacuum tube and its uses (including chapters on practical design), and ends up with complete radio, facsimile, and television systems. This is a truly mammoth undertaking, but by hewing to the line the author manages to succeed in it.

The book is, of course, not perfect. It has all the inevitable faults of a non-mathematical presentation of a very involved mathematical theory. Equations are pulled out of hats right under the nose of the reader. The presentation is at times repetitious in the author's hope that of several explanations of a phenomenon, at least one will seem plausible to the reader.

Furthermore, the presentation is at times uneven and the organization at times jerky. The author uses (and occasionally misuses) capacitance, capacity, and capacitor with complete disregard for the standards. There is no bibliography to help the ambitious student to take the next step in his education. The indexing is only fair.

Erroneous trivia include:

A mild inconsistency in developing some equations in great detail while simply stating other less obvious ones.

An incorrect derivation of a sine wave.

Several dubious statements as to current practice and what is and is not possible.

However, these are minor imperfections. The main fact is that the book cannot help but have been of great assistance to many an aspiring novice. It is easy to understand why it is in its fourth edition.

Knox McIlwain
Hazeltine Electronics Corporation
Little Neck, L. I., N. Y.

An Introduction to the Operational Calculus, First Edition, 1941, by Walter J. Seeley

Published by the International Textbook Company, Scranton, Pa. 162 pages +3-page index+xi pages. 25 figures. $5\frac{1}{2}\times8\frac{1}{2}$ inches. Price, $2.00.

This book is intended for advanced undergraduates and others having a similar mathematical background. It starts with a three-chapter review of the classical method of solution for linear differential equations and passes by natural steps to the operational methods of solution. A considerable number of problems serving to fix the principles already expounded are included at frequent intervals throughout the text and adequate references to the literature to enable the reader who is interested to follow the more advanced portions of the subject are given.

The author is to be congratulated on having produced the most teachable book on this subject which has come to the reviewer's attention. The style is interesting and lucid and although the nature of the subject matter does not make it as easy reading as a detective yarn, the reviewer is of the opinion that most engineers will find it interesting. The book is closed with an appendix consisting of a table of formulas and is provided with an adequate index.

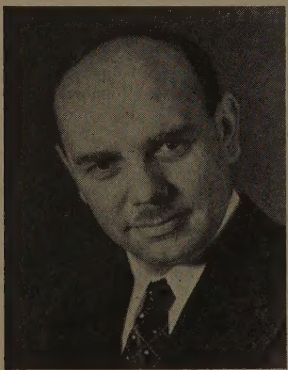
L. P. Wheeler
Federal Communications Commission
Washington, D. C.

Contributors

G. L. Beers

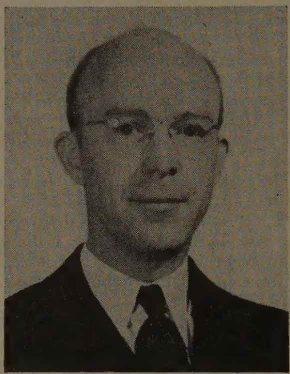
G. L. Beers (A'27–M'29) was born at Indiana, Pennsylvania, in 1899. He received the B.S. degree in electrical engineering from Gettysburg College in 1921. Mr. Beers was in the graduate student course and engineering school of Westinghouse from 1921 to 1922; in the radio engineering department of the Westinghouse Electric and Manufacturing Company, in charge of superheterodyne receiver development, from 1922 to 1930; section engineer in the research department of the RCA Manufacturing Company from 1930 to 1940; in charge of the advanced development division from 1940 to 1942; manager of the engineering and manufacturing service division 1942 to 1943; and since 1943 on the engineering administration staff.

H. A. Breeding was born near Malvern, Iowa. He joined General Electric shortly after his graduation from Iowa State College in 1926 and was elevated to his present position upon graduation from the General Electric Test Course. Since 1928 he has been intimately associated with the entire development and application of gaseous-discharge and vapor lamps, including hot-cathode, neon, sodium and mercury, as well as fluorescent lamps. He designed the thyratron control equipment for the Texas Centennial's plaza lighting and assisted in the lighting of the Chicago Century of Progress and the Golden Gate International Exposition. He laid out and constructed the first sodium street lighting in this country and conceived and designed the first "cooler-than-daylight" television lighting installation. Mr. Breeding has just completed a series of studies on sky glow in conjunction with the United States Army and Navy.



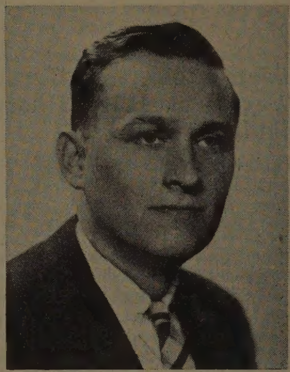
H. A. Breeding

J. E. Hayes (A'39) was born in Arcola, Saskatchewan, on February 14, 1910. He received the degree of B.Sc. in electrical engineering from Queen's University at Kingston, Ontario, in 1935. The following year he joined the engineering department of the Canadian Radio Broadcasting Commission; when the Commission was supplanted by the Canadian Broadcasting Corporation, he became a member of the transmission and development department of the new organization. His work has included rather extensive field intensity, antenna efficiency, and ground-conductivity measurements across Canada. Recently Mr. Hayes has been occupied chiefly with development work supplemented by occasional problems in antenna design.



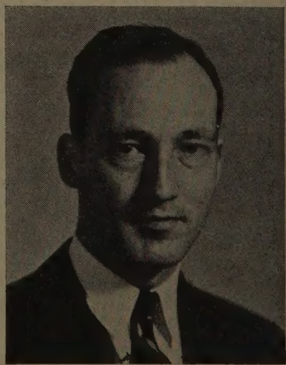
J. E. Hayes

J. A. Ouimet (A'39) was born in Montreal, Canada, in 1908. He received his B.A. degree in 1928 from the University of Montreal and B.Eng. degree in 1932 from McGill University. Mr. Ouimet was research engineer at the Canadian Television and Canadian Electronic Company between 1932 and 1934. He joined the engineering division of the Canadian Radio Broadcasting Commission in 1934 as research engineer and became operations engineer of the Canadian Broadcasting Corporation in 1937 and assistant chief engineer in 1940. He is a member of the Engineering Institute of Canada and Chairman of the Montreal Section of the Institute of Radio Engineers.



J. A. Ouimet

John A. Rodgers (A'38) was born on September 5, 1910, at Niagara Falls, New York. In 1933 he received the A.B. degree from Williams College, and two years later the S.B. degree from the Massachusetts Institute of Technology. During the succeeding six years Mr. Rodgers has done development engineering in radio at the Stromberg-Carlson Telephone Manufacturing Company, where he is now in charge of this company's physical testing laboratory. He is a member of the American Society for Testing Metals.



John A. Rodgers